Teton River Subbasin

2016 Total Maximum Daily Loads and Five-Year Review

Hydrologic Unit Code 17040204

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Abbreviations, Acronyms, and Symbols

§ section (usually a section of federal or state rules or statutes)

§303(d) refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section

§319 refers to section 319 of the Clean Water Act and associated funding for Nonpoint Source Program grants

ADB assessment database

AIZ aquatic influence zone

AU assessment unit

BAG basin advisory group

BKT Brook Trout

BLM United States Bureau of Land Management

BMP best management practice

BURP Beneficial Use Reconnaissance Program

C Celsius

CFR Code of Federal Regulations (refers to citations in the federal administrative rules)

cfs cubic feet per second

CGP Construction General Permit

cm centimeters

CW cold water (aquatic life)

DEQ Idaho Department of Environmental Quality

DO dissolved oxygen

DWS domestic water supply

E. coli *Escherichia coli*

EPA United States Environmental Protection Agency

F Fahrenheit

FTR Friends of the Teton River

GIS geographic information system

HUC hydrologic unit code

IDAPA Refers to citations of Idaho administrative rules

IDFG Idaho Department of Fish and Game

IDL Idaho Department of Lands

IDWR Idaho Department of Water Resources

IWRB Idaho Water Resources Board

kWh kilowatt-hour

LA load allocation

LC load capacity

m meter

MDAT maximum daily average temperature

MDMT maximum daily maximum temperature

mg/L milligrams per liter

mL milliliter

mm millimeter

MOS margin of safety

MS4 municipal separate storm sewer systems

MSGP Multi-Sector General Permit

MWAT maximum weekly average temperature

MWMT maximum weekly maximum temperature

n/a not applicable

NA not assessed

NB natural background

NFS not fully supporting

NO_2^{2-} nitrite

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

NREL National Renewable Energy Laboratory

NTU nephelometric turbidity unit

PCR primary contact recreation

PFC proper functioning condition

PNV potential natural vegetation

QA quality assurance

RBT Rainbow Trout

RMI DEQ's River Macroinvertebrate Index

SCR secondary contact recreation

SEI streambank erosion inventory

SFI DEQ's Stream Fish Index

SHI DEQ's Stream Habitat Index

SMI DEQ's Stream Macroinvertebrate Index

SS salmonid spawning

SWMP stormwater management program

SWPPP stormwater pollution prevention plan

TKN total Kjeldahl nitrogen

TMDL total maximum daily load

TP total phosphorus

USBR United States Bureau of Reclamation

USC United States Code

USDA United States Department of Agriculture

USFS United States Forest Service

USFWS United States Fish and Wildlife Service

USGS United States Geological Survey

WAG watershed advisory group

WBAG *Water Body Assessment Guidance*

WLA wasteload allocation

WWTP wastewater treatment plant

YCT Yellowstone Cutthroat Trout

µ micro, one-one thousandth

Executive Summary

The federal Clean Water Act requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the Clean Water Act, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the Clean Water Act establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards).

States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently, this list is published every 2 years as the list of Category 5 water bodies in Idaho's Integrated Report. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. This document addresses 18 assessment units in the Teton River subbasin for temperature, sediment, and bacteria impairments. Some have been placed in Category 5 of Idaho's most recent federally approved Integrated Report (DEQ 2014), others are unlisted, and still others are receiving updated TMDLs.

This addendum describes the key physical and biological characteristics of the subbasin; water quality concerns and status; pollutant sources; and recent pollution control actions in the Teton River subbasin, located in east-central Idaho. For more detailed information about the subbasin and previous TMDLs, see the *Teton River Subbasin Assessment and Total Maximum Daily Load* (DEQ 2003a,b).

The TMDL analysis establishes water quality targets and load capacities, estimates existing pollutant loads, and allocates responsibility for load reductions needed to return listed waters to a condition meeting water quality standards. It also identifies implementation strategies—including reasonable time frames, approach, responsible parties, and monitoring strategies—necessary to achieve load reductions and meet water quality standards.

In addition, the results of ongoing monitoring and watershed improvement projects are reported in this document and serve as a 5-year review of the original TMDL.

Subbasin at a Glance

The Teton River subbasin is located in eastern Idaho (Figure A). The subbasin is west of Grand Teton Nation Park (Wyoming), with a portion of the subbasin having headwaters in Wyoming. In the upper portion of the subbasin, the largest town is Driggs, but near the Teton River confluence with the Henrys Fork River is the largest town in the subbasin, Rexburg. The Teton River subbasin is divided between Teton and Madison Counties. From its headwaters, the Teton River flows north between the Teton Range and the Big Hole Mountains. The river then curves westward around the Big Hole Mountains on the southern bank and flows west until its confluence with the Henrys Fork River near Rexburg.

Features of the Teton River subbasin, the tributary watersheds, and individual streams are detailed in the 2003 subbasin assessment and TMDL (DEQ 2003a). Comprehensive biological and instream water quality data were presented and analyzed in the 2003 document and supplement (DEQ 2003a, b). This TMDL addendum summarizes pertinent subbasin characteristics and any additional data that affect water quality and beneficial uses in the Teton River subbasin.

There are 2 National Pollutant Discharge Elimination System (NPDES) permits in the subbasin; none are in listed assessment units (AUs) and none are deemed to have detrimental impacts on the receiving waters. Therefore, no action is required. There were no municipal, stormwater, or multi-sector general permit wasteload allocations developed as no municipal separate storm sewer systems or multi-sector general permits exist within the subbasin. Permitted construction general permits are considered in compliance with the intent of the TMDL so long as they follow their permit.

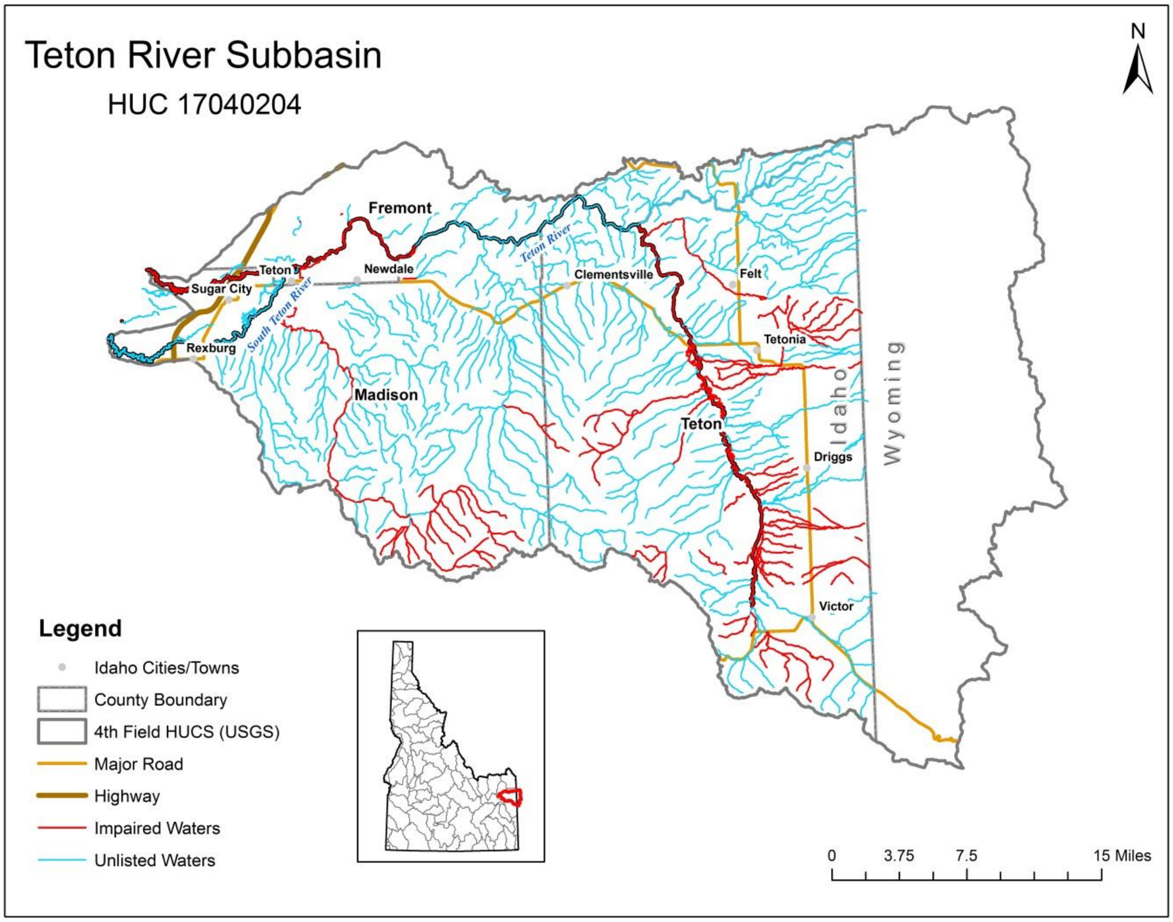

Figure A. Teton River Subbasin.

Key Findings

The Teton River subbasin has multiple AUs that are impaired by various pollutants. The primary pollutants are temperature, sediment, and *E. coli*. Since the 2003 TMDL, improvements to land uses have diminished but not eliminated the pollutant sources to the water bodies that cause impairments to their beneficial uses. However, there are still many AUs where the application and maintenance of best management practices (BMPs) are not sufficient to rectify impairments.

Those TMDLs are still required or new TMDLs have been developed to identify those impairments and needed reductions to meet Idaho water quality standards. Since the majority of the pollutants are from nonpoint sources, the use of BMPs is essential. Temperature and sediment impairments are expected to persist about a decade after mitigation BMPs are applied so that natural stream processes and vegetation can recover. *E. coli* impairments are variable by season; mitigation options, such as exclosure fencing, can cause nearly instant improvements, as was the case in Warm Creek (in the Trail Creek subwatershed). In the case of the Woods Creek wetland region of the Teton River subbasin, the primary source of *E. coli* has been identified as avian in origin rather than from domesticated animals. In this case, alternative mitigation options may be required.

In total, 14 AUs received at least one new or updated TMDL (Table A).

- Temperature was determined to be impairing water quality in 5 unlisted AUs, and temperature load allocations are provided in this document. In addition, 5 AUs received updated temperature TMDLs using the current Idaho Department of Environmental Quality method for estimating shade.
- Sediment was found to be impairing beneficial uses in 1 listed AU, and 2 unlisted AUs; allocations for sediment load reductions are provided in this document. Additionally, 3 AUs received updated TMDLs for sediment impairments.
- *E. coli* was determined to be impairing water quality in 3 AUs; bacteria TMDLs are provided for restoring beneficial uses to these AUs.

A summary of assessment outcomes for listed and unlisted AUs in the 2012 Integrated Report is given in Table B. The “TMDL Completed” column refers to new or updated TMDLs in this addendum based on current determinations of watershed conditions.

Public Participation

This TMDL addendum was developed with participation from the Watershed Advisory Group (WAG, a.k.a.: Henry’s Fork Watershed Council) and the Teton River technical advisory group. The last meeting with the technical advisory group took place in October 2015, after which their comments were taken and used to improve this addendum. DEQ presented this document to the WAG at the November 2015 Annual Watershed Conference and gave the group the opportunity to provide comments and approve the document for public comment. At this point, the group gave their approval for moving forward with the public comment process. Additional participation included meetings, field tours, and sampling with Friends of the Teton River; meetings with Teton Soil Conservation District and the National Resource Conservation Service; and monthly Henry’s Fork Watershed Council meetings.

Table A. Water bodies and pollutants for which TMDLs were developed.

Assessment Unit Name	Assessment Unit Number	Pollutant(s)
South Fork Moody Creek – source to mouth	ID17040204SK006_02	Sedimentation/siltation
North Fork Moody Creek – source to mouth	ID17040204SK007_02	*Escherichia coli*
Teton River – Cache Bridge to Highway 33 Bridge	ID17040204SK017_04	Sedimentation/siltation (update); temperature
Teton River – Teton Creek to Cache Bridge	ID17040204SK020_04	Sedimentation/siltation (update); temperature
Teton River – Teton River – Tributaries between Trail Creek to Teton Creek	ID17040204SK026_02	Temperature (update)
Teton River – Trail Creek to Teton Creek	ID17040204SK026_04	Sedimentation/siltation (update); temperature
Teton River – Warm and Drake Creeks Confluence to Trail Creek	ID17040204SK028_03	Sedimentation/siltation; temperature
Trail Creek – Diversion to mouth	ID17040204SK035_03	Sedimentation/siltation
Fox Creek	ID17040204SK041_02	Temperature (update)
Fox Creek	ID17040204SK042_02	Temperature (update)
Driggs Springs spring creek complex – located between Teton Creek and Woods Creek	ID17040204SK049_02	*Escherichia coli*
Woods Creek	ID17040204SK050_02	*Escherichia coli*
Spring Creek – North Leigh Creek to mouth	ID17040204SK054_03	Temperature (update)
Spring Creek – source to North Leigh Creek	ID17040204SK056_02	Temperature (update)
Spring Creek – source to North Leigh Creek	ID17040204SK056_03	Temperature (update)

Table B. Summary of assessment outcomes for §303(d)-listed and unlisted assessment units.

Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to Next Integrated Report	Justification
ID17040204SK006_02, South Fork Moody Creek – source to mouth	Sedimentation/ siltation	Yes	Place in Category 4a for sediment	Sediment TMDL completed based on streambank stability
ID17040204SK007_02, North Fork Moody Creek – source to mouth	Fecal coliform	Yes	Place in Category 4a for *E. coli*, delist for fecal coliform	*E. coli* TMDL based on geometric mean
ID17040204SK011_02, Warm Creek – source to mouth (Canyon Creek watershed)	Combined biota/habitat bioassessments; fecal coliform	No	Delist combined biota/habitat bioassessments; delist for fecal coliform; move to Category 2	BURP monitoring occurred in a wetland; *E. coli* measured below threshold—listed based on data from Warm Creek (Trail Creek watershed)
ID17040204SK017_04, Teton River – Cache Bridge to Highway 33 Bridge	No 2012 impaired listing	Yes	Place in Category 4a for temperature, retain in 4a for sediment	Potential natural vegetation (PNV) temperature TMDL, excess solar load from a lack of existing shade; sediment loads updated
ID17040204SK020_04, Teton River – Teton Creek to Cache Bridge		Yes		
ID17040204SK026_02, Teton River – Tributaries between Trail Creek to Teton Creek	No 2012 impaired listing	Yes	Retain in Category 4a for temperature, retain in 4a for sediment	Potential natural vegetation (PNV) temperature TMDL, excess solar load from a lack of existing shade
ID17040204SK026_04, Teton River – Trail Creek to Teton Creek	No 2012 impaired listing	Yes	Place in Category 4a for temperature, retain in 4a for sediment	Potential natural vegetation (PNV) temperature TMDL, excess solar load from a lack of existing shade; sediment loads updated
ID17040204SK028_03, Teton River – Warm and Drake Creeks confluence to Trail Creek	No 2012 impaired listing	Yes	Place in Category 4a for temperature and sediment	PNV temperature TMDL, excess solar load from a lack of existing shade; sediment TMDL completed based on streambank stability
ID17040204SK034_02, Warm Creek – source to mouth (Trail Creek watershed)	Combined biota/habitat bioassessments; fecal coliform	No	Delist combined biota/habitat bioassessments; delist for fecal coliform; move to Category 4c for low flow alterations	*E. coli* geometric mean below threshold; land use changes include increased fencing; low flow alterations are sole cause for impairment
ID17040204SK035_03, Trail Creek – diversion to mouth	No 2012 impaired listing	Yes	Place in Category 4a for sediment; place in Category 4c for low flow alterations	Sediment TMDL completed based on streambank stability, stream channel erodes when water is present; low flow alterations are an additional impairment cause
ID17040204SK041_02, Fox Creek	No 2012 impaired listing	Yes	Retain in Category 4a for temperature	Temperature TMDL updated to PNV, excess solar load from a lack of existing shade
ID17040204SK042_02, Fox Creek	No 2012 impaired listing	Yes	Place in Category 4a for temperature	Potential natural vegetation (PNV) temperature TMDL, excess solar load from a lack of existing shade
ID17040204SK046_02, Dick Creek spring complex	Combined biota/habitat bioassessments	No	Delist combined biota/habitat bioassessments; place in 4c for low flow alterations	Low flow alterations are sole cause for impairment
ID17040204SK049_02, Driggs Springs spring creek complex – located between Teton Creek and Woods Creek	*Escherichia coli*	Yes	Place in Category 4a for *E. coli*. Delist fecal coliform.	*E. coli* TMDL based on geometric mean

Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to Next Integrated Report	Justification
ID17040204SK050_02, Woods Creek – source to mouth, including spring creek tributaries		Yes		
ID17040204SK054_03, Spring Creek – North Leigh Creek to Mouth	No 2012 impaired listing	Yes	Retain in Category 4a for temperature	Temperature TMDL updated to PNV, excess solar load from a lack of existing shade
ID17040204SK056_02, Spring Creek – source to North Leigh Creek		Yes		
ID17040204SK056_03, Spring Creek – source to North Leigh Creek		Yes		

Note: All AUs with a Category 4c designation in the 2012 Integrated Report shall be retained in that category (see Table 5 for listings).

Temperature

Idaho's 2012 Integrated Report does not list any AUs in Category 5 for temperature impairments. However, 5 AUs with EPA-approved temperature TMDLs (DEQ 2003a) were updated using the potential natural vegetation (PNV) temperature TMDL methodology: Fox Creek (ID17040204SK041_02), Spring Creek (ID17040204SK054_03, 056_02, and 056_03) and Teton River – Tributaries between Trail Creek to Teton Creek (ID17040204SK026_02). This document also addresses 5 unlisted AUs, all in the main stem Teton River, where monitoring determined temperature exceedances of the salmonid spawning standard: ID17040204SK028_03, 026_04, 020_04, and 017_04.

Effective target shade levels were established for the 10 AUs based on the concept of maximum shading under PNV resulting in natural background temperature levels. Shade targets were derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation that was partially field verified with Solar Pathfinder data. Target and existing shade levels were compared to determine the amount of shade needed to bring water bodies into compliance with temperature criteria in Idaho's water quality standards (IDAPA 58.01.02).

Most streams examined had excess heat loads as a result of lack of shade. The main stem Teton River at its headwaters at the confluence of Drake and Warm Creeks has significant ground water inputs that may be an additional temperature source, but that is not deemed as the causal factor leading to exceedances of the salmonid spawning temperature standard. The upper 2nd-order AU of Fox Creek was the only unit without excess solar load. Most streams require some rehabilitation to achieve shade targets. Target shade levels for individual stream segments should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts.

Sediment/Siltation

Idaho's 2012 Integrated Report lists 1 AU for a sediment-related impairment. South Fork Moody Creek – source to mouth (ID17040204SK006_02) has a TMDL for sediment in this document. TMDLs are also developed in this document for 2 unlisted AUs: Teton River – Warm and Drake

Creeks Confluence to Trail Creek (ID17040204SK028_03) and Trail Creek (ID17040204SK035_03). There were 3 AUs, all in the main stem Teton River, that received updated TMDL load data in that the in-channel load was estimated in this document: ID17040204SK026_04, SK020_04, and SK017_04.

Additional sediment monitoring occurred in 2 AUs to examine if sediment was a potential pollutant: Warm Creek (Trail Creek watershed) (ID17040204SK034_02) and Warm Creek (Canyon Creek watershed) (ID17040204SK011_02). Sediment was not identified as having sufficient sources or pathways to be deemed as an impairment cause in these AUs.

Bacteria

Idaho's 2012 Integrated Report listed 5 AUs for bacteria impairments, either as fecal coliform or *E. coli*. It was determined that 3 AUs required bacteria TMDLs for impairment to the recreation beneficial uses. North Fork Moody Creek – source to mouth (ID17040204SK007_02) had a TMDL developed. Two AUs had a combined TMDL developed: Driggs Springs complex (ID17040204SK049_02) and Woods Creek (ID17040204SK050_02). These AUs flow through a connected peat marsh. Each AU will be monitored individually for future reference.

Due to land use management changes and exclosure fencing, Warm Creek AU ID17040204SK034_02 (Trail Creek watershed) was not found to have a bacteria impairment. Warm Creek AU ID17040204SK011_02 (Canyon Creek watershed) was also not found to have a bacteria impairment. This AU was listed erroneously (data from the Warm Creek [Trail Creek watershed] AU were mistakenly used during assessment) and a 5-sample geometric mean was also calculated determining no impairment. These two AUs should be delisted for fecal coliform.

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Introduction

This document specifically addresses 18 assessment units in the Teton River subbasin. Some have been placed in Category 5 of Idaho's most recent federally approved Integrated Report (DEQ 2014), others are unlisted, and others are receiving revised analyses. The purpose of this total maximum daily load (TMDL) addendum is to characterize and document pollutant loads within the Teton River subbasin. The first portion of this document presents key characteristics or updated information for the subbasin assessment, which is divided into four major sections: subbasin characterization (section 1), water quality concerns and status (section 2), pollutant source inventory (section 3), and a summary of past and present pollution control efforts (section 4). While the subbasin assessment is not a requirement of the TMDL, the Idaho Department of Environmental Quality (DEQ) performs the assessment to ensure impairment listings are up-to-date and accurate.

The subbasin assessment is used to develop a TMDL for each pollutant of concern for the Teton River subbasin. The TMDL (section 5) is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a water body and still allow that water body to meet water quality standards (40 CFR Part 130). Consequently, a TMDL is water body- and pollutant-specific. The TMDL also allocates allowable discharges of individual pollutants among the various sources discharging the pollutant.

In addition, the results of ongoing monitoring and watershed improvement projects are reported in this document and serve as a 5-year review of the original TMDL. Corrections and modifications to the Integrated Report are also included in this document to fully update and integrate the assessment unit (AU) classification system from the water body approach used in the 2003 TMDL (DEQ 2003a).

Regulatory Requirements

This document was prepared in compliance with both federal and state regulatory requirements. The federal government, through the United States Environmental Protection Agency (EPA), assumed the dominant role in defining and directing water pollution control programs across the country. DEQ implements the Clean Water Act in Idaho, while EPA oversees Idaho and certifies the fulfillment of Clean Water Act requirements and responsibilities.

Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act, in 1972. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 USC §1251). The act and the programs it has generated have changed over the years as experience and perceptions of water quality have changed. The Clean Water Act has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to ensure "swimmable and fishable" conditions. These goals relate water quality to more than just chemistry.

The Clean Water Act requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to §303 of the Clean

Water Act, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. DEQ must review those standards every 3 years, and EPA must approve Idaho's water quality standards. Idaho adopts water quality standards to protect public health and welfare, enhance water quality, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

Section 303(d) of the Clean Water Act establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently, this list is published every 2 years as the list of Category 5 waters in Idaho's Integrated Report. For waters identified on this list, states and tribes must develop a TMDL for the pollutants, set at a level to achieve water quality standards.

DEQ monitors waters, and for those not meeting water quality standards, DEQ must establish a TMDL for each pollutant impairing the waters. However, some conditions that impair water quality do not require TMDLs. EPA considers certain unnatural conditions—such as flow alteration, human-caused lack of flow, or habitat alteration—that are not the result of discharging a specific pollutant as "pollution." TMDLs are not required for water bodies impaired by pollution, rather than a specific pollutant. A TMDL is only required when a pollutant can be identified and in some way quantified.

1 Subbasin Assessment—Subbasin Characterization

The Teton River subbasin (hydrologic unit code [HUC] 17040204) is located in east-central Idaho, with portions in Wyoming and abutting the Grand Teton National Park (Figure 1). Three distinct reaches of the Teton River have been defined by the geologic and topographic features of the subbasin.

The Teton River begins at the southern end of the first reach, at the confluence of Warm and Drake Creeks, which is a structural basin referred to as Teton Valley or Teton Basin. This basin is approximately 5 miles wide and 20 miles long and was at one time blocked at its northern end by volcanic deposits. The lake-type depositional area filled with fine-sized debris washed from the alluvial fans that formed at the base of the Teton Range. This produced soils that are poorly drained organic-rich silty clay loams and gravelly loams underlain by a relatively impervious layer of clay. As tributaries flow out of the Teton Range, water can subside into the coarse-sized, well-drained alluvium along the eastern edge of the basin. The water percolates through the soil until it reaches the impervious layer and then apparently flows along this surface until it re-emerges as springs and seeps approximately 2–3 miles west of the point at which it subsided. These conditions create the wetlands of the Teton River Valley.

The second reach of the Teton River includes the canyon that it carved through the felsic and basaltic volcanic deposits of the subbasin. At its confluence with Bitch Creek, a major tributary, the river makes an almost 90^{o} turn to the west. Teton Canyon, with steep walls rising as high as 500 feet, contains the river for approximately 17 miles. In 1975, Teton Dam was completed at the lower end of the canyon (northeast of Newdale) to create a reservoir for irrigation water. In

June 1976, when the reservoir behind the dam had almost filled, the earthen dam collapsed. More than 250,000 acre-feet of water and 4 million cubic yards of embankment material flowed through the breach in less than 6 hours.

The third reach of the river extends from the Teton Dam site to the Henrys Fork and includes the floodplains of the North and South Forks of the Teton River and the Henrys Fork River. This reach was extensively altered by the flood that followed the collapse of the Teton Dam, and by the mitigation and restoration work that followed.

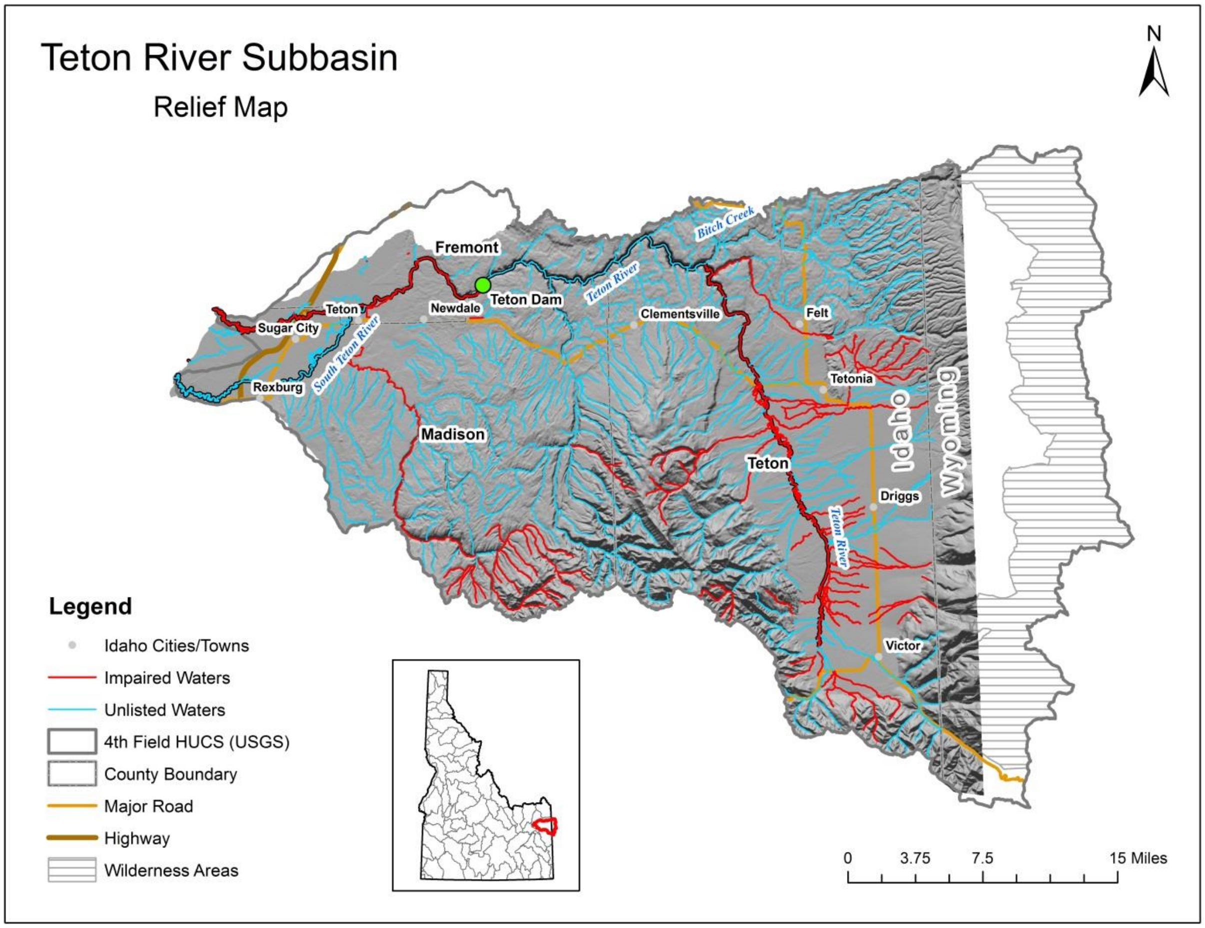

Figure 1. Shaded relief map of the Teton River subbasin in Idaho.

1.1 Climate and Hydrology

At least five climate stations are in or near the Teton River subbasin. The period of record extends from August 1, 1904, through September 30, 2012. The data are from the Western Regional Climate Center weather stations (Table 1) (Western Regional Climate Center 2013).

Agriculture has long been established in the Teton River subbasin. Since much of the agricultural region is semi-arid, averaging approximately 12.5 inches in the lower subbasin and 18 inches in the upper basin agricultural areas, surface water is extensively diverted for irrigation. In progressively higher elevations up the slopes of the subbasin, precipitation increases, as evidenced by the precipitation at the Alta 1 NW weather station (Table 1).

Table 1. Weather station data for the Teton River subbasin.

Weather Station	Date Range	Average Maximum Temperature (°F)	Average Minimum Temperature (°F)	Average Total Precipitation (inches)	Average Total Snowfall (inches)
Rexburg Ricks College, Idaho (107644)	7/1/1977–9/30/2012	56.5	30.2	13.03	52.9
Sugar, Idaho (108818)	8/1/1907–7/31/2012	56.2	28.0	11.81	49.9
Tetonia Experiment Stn., Idaho (109065)	4/1/1950–9/30/2012	53.0	25.5	16.78	28.0
Driggs, Idaho (102676)	8/1/1904–9/30/2012	53.9	25.9	16.01	65.2
Alta 1 NW, Wyoming (480140)	7/18/1909–9/30/2012	52.6	26.6	21.92	109.8
Average		**54.4**	**27.2**	**15.91**	**61.2**

Stream discharges in the Teton River subbasin are generally a function of snowmelt runoff. Peak discharges occur in May or June when average total precipitation reaches a maximum and warmer average daily temperatures accelerate snowmelt. In the upper subbasin, two periods of peak flow are associated with two distinct snowmelt periods. The first occurs when snow at lower elevations melts in March and April; the second occurs when snow at higher elevations melts in late May and June and is accompanied by rainfall. Many of the streams that originate in the Teton and Big Hole Mountain Ranges do not connect to the Teton River except during periods of peak flow.

The US Geological Survey (USGS) has operated gage stations at 24 locations within the Teton River subbasin, though only 4 stations are currently operating. The periods of record at those 4 gage are listed in Table 2. Discharge data are available from the USGS National Water Information System website. Several of the discontinued stations were located on tributary streams in the upper subbasin, and most of these were operational only from 1946 through the early 1950s (DEQ 2003a).

Table 2. Summary of discharge data at US Geological Survey stream gaging stations.

Gaging Station		Period of Record[a]
13052200	Teton River above South Leigh Creek near Driggs ID	1961–2014
13055000	Teton River near St Anthony ID	1890–1893 1903–1909 1920–1921 1923–1933 1933–1976 1977–2014
13055250	NF Teton River near Sugar City ID	2003–2014
13055340	SF Teton River near Rexburg ID	1981–2014

[a] Dates are for the data available at the time of developing this TMDL.

The Teton River originates from headwater streams in the Teton, Snake River, and Big Hole Mountain Ranges and flows more than 64 miles to the point at which it discharges to the Henrys Fork of the Snake River. Approximately 16 river miles upstream from its discharge point, the Teton River divides into two channels. On USGS topographic maps, the northernmost channel is named Teton River and the southernmost channel is named South Teton River. But these channels are more commonly known as the North Fork and South Fork Teton River (DEQ 2003a) and are referred to as such throughout this document.

1.2 Subbasin Characteristics

The Teton River subbasin (HUC 17040204) is located in east-central Idaho and Wyoming (Figure 1). The Teton River originates in the valley bottom at the confluence of Warm Creek (Trail Creek watershed) and Drake Creek, but multiple tributaries originate in the Big Hole Mountains and the Teton Mountain Range and the river has significant inputs from ground water sources. The Teton River flows northward before making a large western curve to join the Henrys Fork of the Snake River near Rexburg, approximately 7 miles upstream of the confluence with the Snake River.

Agricultural management activities can impact water quality through cropland runoff or by streambanks becoming unstable from livestock trampling, which can promote excess sediment load. These activities also have the potential to remove vegetative cover that would normally stabilize streambanks and provide shade. Irrigation withdrawals for cropland have been extensive throughout the Teton River subbasin. DEQ has no jurisdiction over water rights and does not provide load allocations for flow alteration.

Three mountain ranges define the eastern, southeastern, and south-central boundaries of the subbasin: the Teton, Snake River, and Big Hole mountain ranges. The Teton Valley, a north-south trending valley, is defined by the convergence of these three mountain ranges. Elevations exceeding 10,000 feet occur along the entire length of the eastern boundary of the subbasin in the Teton Range. Streams originating from the Teton Range may drop as much as 4,000 feet in elevation as they flow a horizontal distance of less than 15 miles toward the Teton Valley. The extreme eastern portion of the subbasin and the highest portions of the Teton Range are located in Wyoming; locations within Wyoming are not examined nor are they discussed in this document.

1.3 Landownership and Population

Since the original TMDL and supplement (DEQ 2003a, b), the delineation of many watersheds has been altered by a cooperative effort among the Idaho Department of Water Resources (IDWR), the Natural Resources Conservation Service (NRCS), and various state and local agencies. The Idaho Watershed Boundary 5th and 6th Field Delineation Project (IDWR 2008) implemented changes in many Idaho watershed boundaries to coordinate with surrounding states and more accurately reflect drainage patterns. Consequently, for the Teton River subbasin, the total acreage, proportions in landownership distribution, and other land area characteristics may differ from the original TMDL analysis and implementation plan. Table 3 and Figure 2 detail the current landownership for this subbasin.

Table 3. Current landownership in the Teton River subbasin (Idaho portion only).

Owner/Land Manager	Acreage	Percent of Basin
Bureau of Land Management	10,443	1.98%
Bureau of Reclamation	2,858	0.54%
Private	389,835	73.81%
State	18,416	3.49%
US Forest Service	106,581	20.18%
Total	**528,134**	**100.00%**

The Idaho portion of this subbasin is approximately 74% private land, most of which is in agriculture. The United States Forest Service (USFS) Caribou-Targhee National Forest manages the upland regions and forested slopes. The river valley is predominantly privately owned. Small segments are managed by the United States Bureau of Land Management (BLM) and United States Bureau of Reclamation (USBR). The subbasin falls into several counties, with the greater portion being in Teton and Madison Counties. A portion of the subbasin enters and borders Freemont County in and downstream of the Bitch Creek watershed.

The land area in this subbasin is almost all rural. The 2010 population of 10,170 residents in Teton County increased from 5,999 in 2000. The county is sparsely populated, with less than 23 residents per square mile. The city of Driggs, in Teton County, had 1,994 residents in 2010. Rexburg, in Madison County (near the Teton River–Henrys Fork confluence), had 25,484 residents in 2010, an increase from 17,257 in 2000. The 2010 population of 37,536 residents in Madison County increased from 27,467 in 2000. In 2010, the county had 80 residents per square mile (US Census Bureau 2013). The growth in Madison County and Rexburg is due in great part to the conversion of the 2-year Ricks College to the 4-year BYU-Idaho. Only a portion of the city of Rexburg falls within the Teton River subbasin boundary.

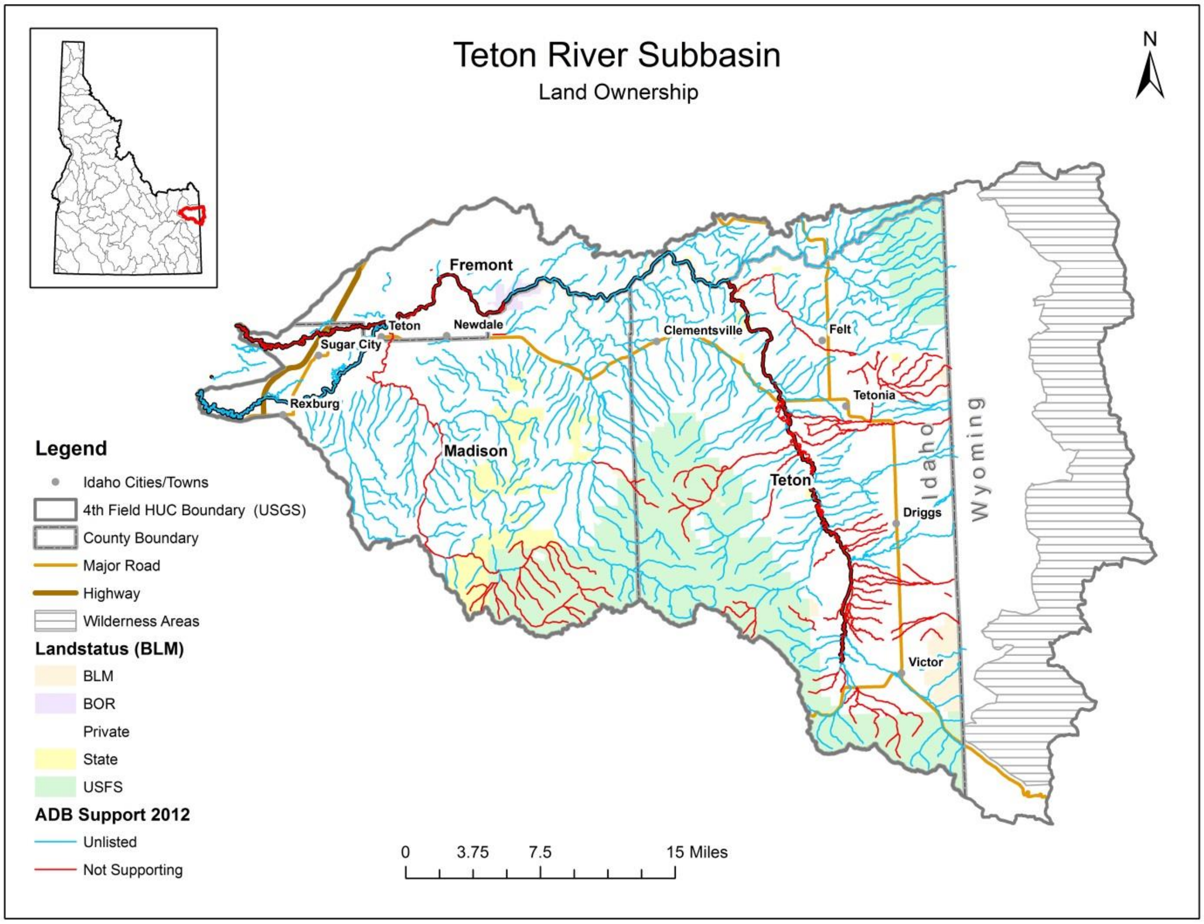

Figure 2. Landowner distribution (BLM 2010).

1.4 Economics

Employment in Teton County is predominantly in the leisure and service industries and state and local government. Much of the economy is reliant upon tourism (Idaho Department of Labor 2013a). In Madison County, trade-based professions compose nearly a quarter of employment due to retail and wholesale positions (Idaho Department of Labor 2013b). Both counties have had significant increases in unemployment since 2007.

1.5 Yellowstone Cutthroat Trout

Of special concern in the Teton River subbasin is the spawning habitat and associated population of Yellowstone Cutthroat Trout (*Onchorhynchus clarkii bouvieri*). A 2006 determination by the US Fish and Wildlife Service (USFWS) not to list the Yellowstone Cutthroat Trout (YCT) under the Endangered Species Act (Federal Register 2006) has not diminished the regional and local concerns for its successful perpetuation in the Teton River, particularly in the valley section. The Idaho Department of Fish and Game's (IDFG's) *Fisheries Management Plan 2013–2018* describes the changes in hydrology and land management that have contributed to declines in the populations and objectives and programs to conserve the native Cutthroat Trout resource. The

IDFG management plan also described a recovery in YCT populations since 2003 and that the overall trout abundance has also increased, as detailed in section 4.2.8 (IDFG 2013; Dan Garren, personal communication, 2014). YCT decline was related to habitat alterations from cattle grazing, sedimentation, and stream channel widening (IDFG 2013). While funding existed, causal factors were being ameliorated in conjunction with landowners through the Teton River Enhancement Program.

2 Subbasin Assessment—Water Quality Concerns and Status

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

Section 303(d) of the Clean Water Act states that waters that are unable to support their beneficial uses and do not meet water quality standards must be listed as water quality limited. Subsequently, these waters are required to have TMDLs developed to bring them into compliance with water quality standards.

2.1.1 Assessment Units

AUs are groups of similar streams that have similar land use practices, ownership, or land management. However, stream order is the main basis for determining AUs—even if ownership and land use change significantly, the AU usually remains the same for the same stream order.

Using AUs to describe water bodies offers many benefits, primarily that all waters of the state are defined consistently. AUs are a subset of water body identification numbers, which allows them to relate directly to the water quality standards.

While developing this subbasin assessment, several digitizing and data entry errors were identified (e.g., portions of an AU being misentered into a nearby AU). These will be accounted for in full in the next Integrated Report and are not presented or updated in this document.

2.1.2 Listed Waters

Table 4 shows the pollutants listed and the basis for listing for each §303(d)-listed AU in the subbasin (i.e., AUs in Category 5 of the Integrated Report).

Table 4. Teton River subbasin §303(d)-listed assessment units in the subbasin.

Assessment Unit Name	Assessment Unit Number	Listed Pollutants	Listing Basis
South Fork Moody Creek – source to mouth	ID17040204SK006_02	Sedimentation/siltation	2010 §303(d) list
North Fork Moody Creek – source to mouth	ID17040204SK007_02	Fecal coliform	2002 §303(d) list
Warm Creek – source to mouth (Canyon Creek watershed)	ID17040204SK011_02	Combined biota/habitat bioassessments; fecal coliform	2002 §303(d) list
Warm Creek – source to mouth (Trail Creek watershed)	ID17040204SK034_02	Combined biota/habitat bioassessments; fecal coliform	2002 §303(d) list
Dick Creek spring complex – south to Darby Creek and north to Teton Creek	ID17040204SK046_02	Combined biota/habitat bioassessments	2002 §303(d) list
Driggs Springs spring creek complex – located between Teton Creek and Woods Creek	ID17040204SK049_02	*Escherichia coli*	2010 §303(d) list
Woods Creek	ID17040204SK050_02	*Escherichia coli*	2008 §303(d) list

The 2012 Integrated Report has 16 AUs that are impaired by nonpollutants (Category 4c) (Table 5). No TMDL will be developed for the AUs in Category 4c based on biologic data; impairments to narrative or applicable numeric standards (e.g., temperature, sediment, and bacteria) will receive TMDLs.

Table 5. Assessment units reported in Category 4c, "Waters Not Impaired by a Pollutant," of the 2012 Integrated Report.

Assessment Unit Name	Assessment Unit ID Number	Impaired Stream Miles	Pollution
North Fork Teton River – Teton River Forks to Henrys Fork	ID17040204SK002_05	17	Low flow alterations
Teton River – Felt Dam outlet to Milk Creek	ID17040204SK014_04	1.66	Physical substrate habitat alterations
Teton River – Felt Dam pool	ID17040204SK015_04	4.12	
Teton River – Highway 33 Bridge to Felt Dam pool	ID17040204SK016_04	3.26	
Teton River – Cache Bridge to Highway 33 Bridge	ID17040204SK017_04	13.92	
Packsaddle Creek	ID17040204SK019_02	14.58	Other flow regime alterations
Teton River – Teton Creek to Cache Bridge	ID17040204SK020_04	13.72	Physical substrate habitat alterations
Horseshoe Creek	ID17040204SK021_03	4.81	Low flow alterations
Mahogany Creek	ID17040204SK025_02	7.01	Other flow regime alterations
Teton River – tributaries between Trail Creek to Teton Creek	ID17040204SK026_02	22.34	
Teton River – Trail Creek to Teton Creek	ID17040204SK026_04	6.46	Physical substrate habitat alterations
Teton River – Warm and Drake Creeks confluence to Trail Creek	ID17040204SK028_03	2.6	
Drake Creek – source to mouth	ID17040204SK032_02	5.43	
Fox Creek	ID17040204SK041_02	7.98	Other flow regime alterations
	ID17040204SK042_02	0.91	
Spring Creek – source to North Leigh Creek, including spring	ID17040204SK056_02	24.2	

2.1.3 Unlisted Waters

TMDLs were developed for 5 AUs that were not listed in Category 5 of the 2012 Integrated Report. These waters were found to have impairments during monitoring and development of this document (Table 6).

Table 6. Teton River subbasin assessment units with TMDLs developed but not listed in the 2012 Integrated Report.

Assessment Unit Name	Assessment Unit Number	Pollutants
Teton River – Cache Bridge to Highway 33 Bridge	ID17040204SK017_04	Temperature
Teton River – Teton Creek to Cache Bridge	ID17040204SK020_04	Temperature
Teton River – Trail Creek to Teton Creek	ID17040204SK026_04	Temperature
Teton River – Warm and Drake Creeks Confluence to Trail Creek	ID17040204SK028_03	Sediment; temperature
Trail Creek – diversion to mouth	ID17040204SK035_03	Sediment

2.1.4 Supplemented or Updated AUs

There were 8 AUs that had supplements or updates to their existing TMDLs and are listed in Category 4a of the 2012 Integrated Report (Table 7).

Table 7. Teton River subbasin assessment units with TMDLs (Category 4a) that are updated/supplemented in this document.

<table>
<tr><th>Assessment Unit Name</th><th>Assessment Unit Number</th><th>Pollutants</th></tr>
<tr><td>Teton River – Cache Bridge to Highway 33 Bridge</td><td>ID17040204SK017_04</td><td rowspan="3">Sediment</td></tr>
<tr><td>Teton River – Teton Creek to Cache Bridge</td><td>ID17040204SK020_04</td></tr>
<tr><td>Teton River – Trail Creek to Teton Creek</td><td>ID17040204SK026_04</td></tr>
<tr><td rowspan="2">Fox Creek</td><td>ID17040204SK041_02</td><td rowspan="5">Temperature (PNV)</td></tr>
<tr><td>ID17040204SK042_02</td></tr>
<tr><td>Spring Creek - North Leigh Creek to Mouth</td><td>ID17040204SK054_03</td></tr>
<tr><td rowspan="2">Spring Creek – source to North Leigh Creek</td><td>ID17040204SK056_02</td></tr>
<tr><td>ID17040204SK056_03</td></tr>
</table>

2.2 Applicable Water Quality Standards and Beneficial Uses

Idaho water quality standards (IDAPA 58.01.02) list beneficial uses and set water quality goals for waters of the state. Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as described briefly in the following paragraphs. The *Water Body Assessment Guidance* (Grafe et al. 2002) provides a more detailed description of beneficial use identification for use assessment purposes.

Beneficial uses include the following:

- Aquatic life support—cold water, seasonal cold water, warm water, salmonid spawning, and modified
- Contact recreation—primary (swimming) or secondary (boating)
- Water supply—domestic, agricultural, and industrial
- Wildlife habitats
- Aesthetics

2.2.1 Existing Uses

Existing uses under the Clean Water Act are "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards" (40 CFR 131.3). The existing instream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.051.01). Existing uses need to be protected, whether or not the level of water quality to fully support the uses currently exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a water that has supported salmonid spawning since November 28, 1975, but does not now due to other factors, such as blockage of migration, channelization, sedimentation, or excess heat.

2.2.2 Designated Uses

Designated uses under the Clean Water Act are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained" (40 CFR 131.3). Designated uses are simply uses officially recognized by the state. In Idaho, these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Multiple uses often apply to the same water; in this case, water quality must be sufficiently maintained to meet the most sensitive use (designated or existing). Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are described in the Idaho water quality standards (IDAPA 58.01.02.100) and specifically listed by water body in sections 110–160.

2.2.3 Undesignated Surface Waters

In Idaho, due to a change in scale of cataloging waters in 2000, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations (IDAPA 58.01.02.110–160). These undesignated surface waters ultimately need to be designated for appropriate uses. In the interim, and absent information on existing uses, DEQ presumes most of these waters will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called *presumed uses*, DEQ applies the cold water and recreation use criteria to undesignated waters. If in addition to presumed uses, an additional existing use (e.g., salmonid spawning) exists, then the additional numeric criteria for salmonid spawning would also apply (e.g., intergravel dissolved oxygen, temperature) because of the requirement to protect water quality for that existing use. However, if some other use that requires less stringent criteria for protection (such as seasonal cold water aquatic life) is found to be an existing use, then a use designation (rulemaking) is needed before that use can be applied in lieu of cold water criteria.

2.2.4 Beneficial Uses in the Subbasin

Beneficial uses for streams addressed in this addendum are listed in Table 8 and Table 9.

Table 8. Teton River subbasin beneficial uses of §303(d)-listed streams.

Assessment Unit Name	Assessment Unit Number	Designated, Existing, or Presumed Beneficial Uses[a]
South Fork Moody Creek – source to mouth	ID17040204SK006_02	CW, SCR
North Fork Moody Creek – source to mouth	ID17040204SK007_02	CW, SCR
Warm Creek – source to mouth (Canyon Creek watershed)	ID17040204SK011_02	CW, SCR
Warm Creek – source to mouth (Trail Creek watershed)	ID17040204SK034_02	CW, SCR
Dick Creek spring complex – south to Darby Creek and north to Teton Creek	ID17040204SK046_02	CW, SCR
Driggs Springs spring creek complex – located between Teton Creek and Woods Creek	ID17040204SK049_02	CW, SCR
Woods Creek	ID17040204SK050_02	CW, SCR

[a] Cold water aquatic life (CW), secondary contact recreation (SCR)

Table 9. Teton River subbasin beneficial uses of unlisted streams that had TMDLs developed or updated.

Assessment Unit Name	Assessment Unit Number	Designated, Existing, or Presumed Beneficial Uses[a]
Teton River – Cache Bridge to Highway 33 Bridge	ID17040204SK017_04	CW, SS, DWS, PCR
Teton River – Teton Creek to Cache Bridge	ID17040204SK020_04	CW, SS, DWS, PCR
Teton River – Trail Creek to Teton Creek	ID17040204SK026_04	CW, SS, DWS, PCR
Teton River – Warm and Drake Creeks confluence to Trail Creek	ID17040204SK028_03	CW, SS, DWS, PCR
Trail Creek – diversion to mouth	ID17040204SK035_03	CW, SCR
Fox Creek	ID17040204SK041_02 ID17040204SK042_02	CW, SCR
Spring Creek – North Leigh Creek to Mouth	ID17040204SK054_03	CW, SCR
Spring Creek – source to North Leigh Creek	ID17040204SK056_02 ID17040204SK056_03	CW, SCR

[a] Cold water aquatic life (CW), salmonid spawning (SS), primary contact recreation (PCR), secondary contact recreation (SCR), domestic water supply (DWS)

2.2.5 Water Quality Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of water quality criteria, which include *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity, and *narrative* criteria for pollutants such as sediment and nutrients (IDAPA 58.01.02.250–251) (Table 10). For more information, see Appendix A.

Table 10. Selected numeric criteria supportive of designated beneficial uses in Idaho water quality standards.

Parameter	Primary Contact Recreation	Secondary Contact Recreation	Cold Water Aquatic Life	Salmonid Spawning[a]
Water Quality Standards: IDAPA 58.01.02.250–251				
Bacteria				
• Geometric mean	<126 *E. coli*/100 mL[b]	<126 *E. coli*/100 mL	—	—
• Single sample	≤406 *E. coli*/100 mL	≤576 *E. coli*/100 mL	—	—
pH	—	—	Between 6.5 and 9.0	Between 6.5 and 9.5
Dissolved oxygen (DO)	—	—	DO exceeds 6.0 milligrams/liter (mg/L)	**Water Column DO**: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater **Intergravel DO**: DO exceeds 5.0 mg/L for a 1-day minimum and exceeds 6.0 mg/L for a 7-day average
Temperature[c]	—	—	22 °C or less daily maximum; 19 °C or less daily average **Seasonal Cold Water**: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average **Bull Trout**: Not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June–August; not to exceed 9 °C daily average in September and October
Turbidity	—	—	Turbidity shall not exceed background by more than 50 nephelometric turbidity units (NTU) instantaneously or more than 25 NTU for more than 10 consecutive days.	—
Ammonia	—	—	Ammonia not to exceed calculated concentration based on pH and temperature.	—
EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR Part 131				
Temperature	—	—	—	7-day moving average of 10 °C or less maximum daily temperature for June–September

[a] During spawning and incubation periods for inhabiting species
[b] *Escherichia coli* per 100 milliliters
[c] Temperature exemption: Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the 90th percentile of the 7-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.

Narrative criteria for excess sediment are described in the water quality standards:

> Sediment shall not exceed quantities specified in Sections 250 and 252, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350. (IDAPA 58.01.02.200.08)

Narrative criteria for excess nutrients are described in the water quality standards:

> Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses. (IDAPA 58.01.02.200.06)

Narrative criteria for floating, suspended, or submerged matter are described in the water quality standards:

> Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities. (IDAPA 58.01.02.200.05)

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.050.02. The procedure relies heavily on biological parameters and is presented in detail in the *Water Body Assessment Guidance* (Grafe et al. 2002). This guidance requires DEQ to use the most complete data available to make beneficial use support status determinations (Figure 3).

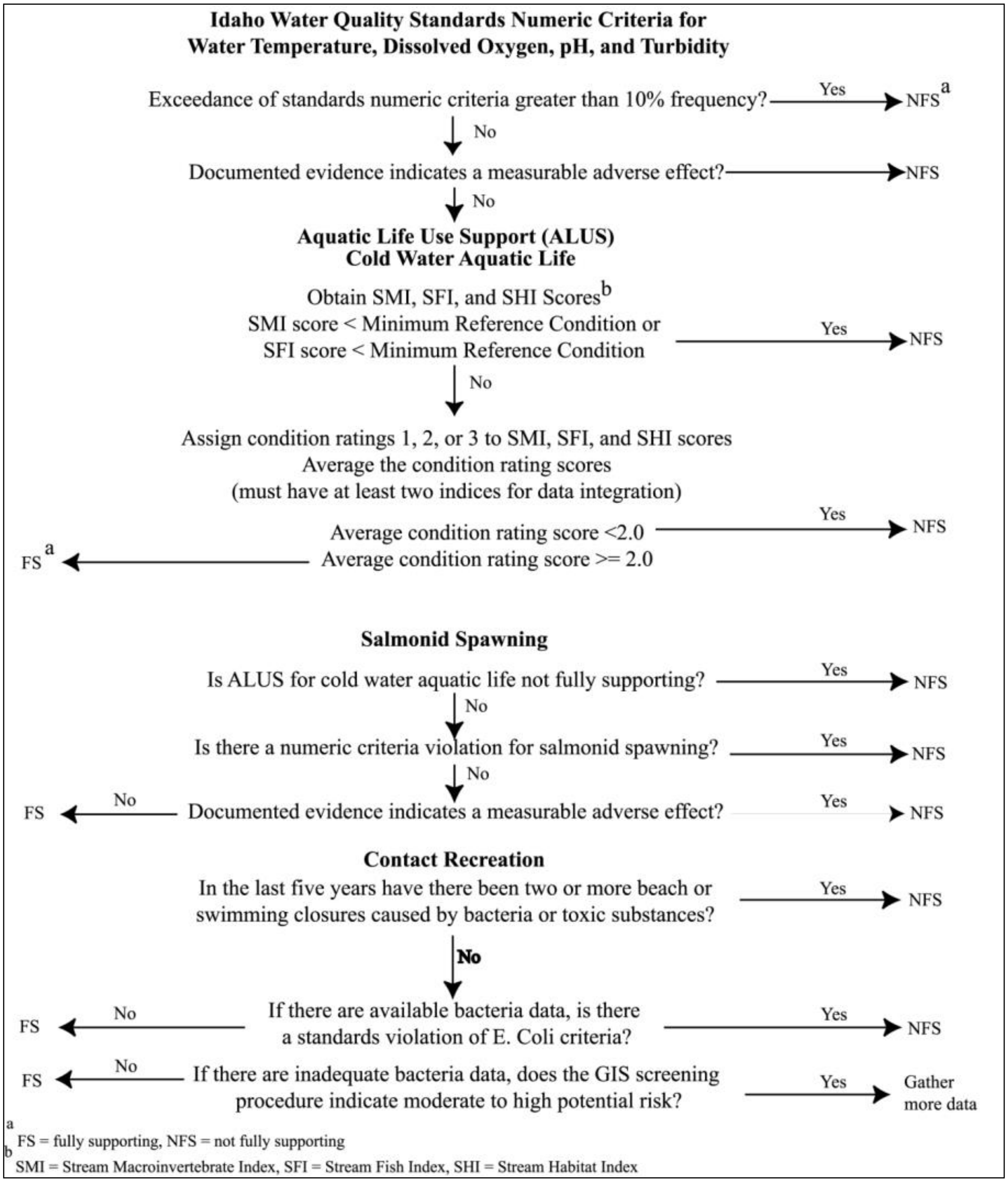

Figure 3. Steps and criteria for determining support status of beneficial uses in wadeable streams (Grafe et al. 2002).

2.3 Status of Beneficial Uses

Three primary pollutants are leading to diminished beneficial uses in the Teton River subbasin: sediment, *E. coli*, and temperature. White there are additional concerns with nutrients, study results from 2012–2013 indicate that sediment is the primary source of these nutrients into the aquatic system. Mitigating the sediment inputs should have positive effects on the nutrient concentrations downstream. Nutrient sources are primarily nonpoint.

2.4 Assessment Unit Summary

A summary of the data analysis, literature review, and field investigations and a list of conclusions for AUs included in Category 5 of the 2012 Integrated Report follows. This section includes changes that will be documented in the next Integrated Report once the TMDLs in this document have been approved by EPA.

ID17040204SK006_02, **South Fork Moody Creek**

- Listed for sedimentation/siltation.
- TMDL created for excessive sediment load—load reduction of 1,860 tons/year (see section 5.2 for details). State Creek was identified as the primary source.
- Place in Category 4a for sediment/siltation. Remove from Category 5.

ID17040204SK007_02, **North Fork Moody Creek**

- Listed for fecal coliform.
- *E. coli* TMDL developed with 85% load reductions required to meet the 126 organisms/100 mL standard (see section 5.3 for details).
- Place in Category 4a for *E. coli*. Remove from Category 5 for fecal coliform.

ID17040204SK011_02, **Warm Creek (Canyon Creek watershed)**

- Listed for combined biota/habitat bioassessment and fecal coliform.
- This AU was listed for combined biota/habitat bioassessment based on legacy issues and database mistakes. Beneficial Use Reconnaissance Program (BURP) monitoring in 1997 occurred in a wetland, producing erroneous results. Elevated drop culvert at the confluence with Canyon Creek alters hydrologic connection and fish scores. See Appendix B for details.
- This AU was listed in error for fecal coliform with data from Warm Creek AU ID17040204SK034_02). Actual values were 40 organisms/100 mL measured for both fecal coliform and *E. coli* (see section 5.3 and Appendix B for details). Follow-up monitoring in 2011 calculated a 5-sample geometric mean of 44 organisms/100 mL.
- Place in Category 2; remove from Category 5 for combined biota/habitat bioassessment and fecal coliform.

ID17040204SK017_04, **Teton River – Cache Bridge to Highway 33 Bridge**

- This listing was updated to include in-channel sources of sediment and load reductions from that specific source. Conclusions and loads from the 2003 TMDL are still in effect (see section 5.2 and Appendix C for details).
- Monitoring identified temperature exceedances of the salmonid spawning criteria.
- Temperature TMDL created with 14% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Retain in Category 4a for sediment/siltation.
- Place in Category 4a for temperature.

ID17040204SK020_04, **Teton River – Teton Creek to Cache Bridge**

- This listing was updated to include in-channel sources of sediment and load reductions from that specific source. Conclusions and loads from the 2003 TMDL are still in effect (see section 5.2 and Appendix C for details).
- Monitoring identified temperature exceedances of the salmonid spawning criteria.
- Temperature TMDL created with 27% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Retain in Category 4a for sediment/siltation.
- Place in Category 4a for temperature.

ID17040204SK026_02, **Teton River – Tributaries between Trail Creek to Teton Creek**

- Temperature TMDL updated created with 22% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Retain in Category 4a for sediment/siltation.
- Retain in Category 4a for temperature.

ID17040204SK026_04, **Teton River – Trail Creek to Teton Creek**

- This listing was updated to include in-channel sources of sediment and load reductions from that specific source. Conclusions and loads from the 2003 TMDL are still in effect (see section 5.2 and Appendix C for details).
- Monitoring identified temperature exceedances of the salmonid spawning criteria.
- Temperature TMDL created with 65% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Retain in Category 4a for sediment/siltation.
- Place in Category 4a for temperature.

ID17040204SK028_03, **Teton River – confluence Warm and Drake Creeks to Trail Creek**

- Found to be a source of sediment to downstream AUs and a TMDL was developed (see section 5.2 and Appendix C for details).
- Excessive bank erosion and silt deposits on substrate were identified in-channel. A load reduction of 244 tons/year is recommended.
- Monitoring identified temperature exceedances of the salmonid spawning criteria.
- Temperature TMDL created with 29% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Place in Category 4a for sediment/siltation.
- Place in Category 4a for temperature.

ID17040204SK034_02, **Warm Creek (Trail Creek watershed)**

- Listed for combined biota/habitat bioassessment and fecal coliform.
- Combined biota/habitat bioassessment listing was based on 1997 BURP scores. However, the assessed section was a straightened reach serving as a canal through an agricultural field. In many locations, the channel is fenced and developing riparian habitat but is still confined to the fenced area. Hydromodifications are the sole cause of the combined biota/habitat bioassessment listing.

- In 2011, a 5-sample geometric mean for *E. coli* was 51 organisms/100 mL. Changes in farming practices, increased urbanization, and exclosure fencing have led to the decreases and meeting standards.
- Move to Category 4c for other flow regime alterations. Remove from Category 5 for combined biota/habitat bioassessment and fecal coliform.

ID17040204SK035_03, Trail Creek – Trail Creek pipeline diversion (SW ¼, SE ¼, Sec 19, T3N, R46E) to mouth

- Listed in Category 3 (unassessed).
- TMDL created for excessive sediment load—load reduction of 813 tons/year (see section 5.2 for details). When water is present, this stream becomes a source of sediment to the Teton River.
- Place in Category 4a for sediment/siltation.
- Place in Category 4c for low flow alterations.

ID17040204SK041_02, Fox Creek

- This temperature listing was updated using a potential natural vegetation (PNV)-based temperature TMDL, with 35% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Retain in Category 4a for temperature.

ID17040204SK042_02, Fox Creek

- This temperature listing was updated using a PNV-based temperature TMDL, with 0% load reductions required to meet the temperature standard (see section 5.1 for details).
- Place in Category 2. Remove from Category 4a for temperature.

ID17040204SK046_02, Dick Creek spring complex

- Listed for combined biota/habitat bioassessment.
- Combined biota/habitat bioassessment listing was based on 1997 BURP scores. However, the assessed section was a straightened reach serving as a canal through an agricultural field confined on both the upper and lower end by roads and highways. Habitat conditions are related to the channel being a canal; it is a poorly maintained canal developing sinuosity and riparian vegetation as urbanization develops in the area, but it is modified for transport of agricultural waters.
- Place in Category 4c for low flow alterations. Remove from Category 5 for combined biota/habitat bioassessment.

ID17040204SK049_02, Driggs Springs complex

- Listed for *E. coli*.
- This AU is being managed along with ID17040204SK050_02 as they exist in a hydrologically interconnected peat bog/wetland. A genetic study from 2006 found the primary *E. coli* source to be from avian/waterfowl sources. A 34% load reduction is required to meet the 126 organisms/100 mL standard (see section 5.3 for details).
- Place in Category 4a for *E. coli*. Delist from Category 5 for fecal coliform.

ID17040204SK050_02, **Woods Creek**

- Listed for *E. coli*.
- This AU is being managed along with ID17040204SK049_02 as they exist in a hydrologically interconnected peat bog/wetland. A genetic study from 2006 found the primary *E. coli* source to be from avian/waterfowl sources. A 34% load reductions required to meet the 126 organisms/100 mL standard (see section 5.3 for details).
- Place in Category 4a for *E. coli*. Delist from Category 5 for fecal coliform.

ID17040204SK054_03, **Spring Creek – North Leigh Creek to mouth**

- This temperature listing was updated using a PNV-based temperature TMDL, with 11% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Retain in Category 4a for temperature.

ID17040204SK056_02, **Spring Creek – source to North Leigh Creek**

- This temperature listing was updated using a PNV-based temperature TMDL, with 43% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Retain in Category 4a for temperature.

ID17040204SK056_03, **Spring Creek – source to North Leigh Creek**

- This temperature listing was updated using a PNV-based temperature TMDL, with 15% load reductions required to meet the temperature standard (see section 5.1 for details). This AU is shade limited.
- Retain in Category 4a for temperature.

3 Subbasin Assessment—Pollutant Source Inventory

Pollution within the Teton River subbasin is primarily from temperature, sediment, bacteria, and nutrients. Load allocations were established in the TMDL approved by EPA in February and September 2003 (DEQ 2003a, b). This document continues the process of identifying and allocating pollutant loads to protect beneficial uses of the waters of Idaho.

3.1 Point Sources

There are two National Pollutant Discharge Elimination System (NPDES) permits of primary concern for this TMDL, both of which are municipal wastewater treatment plants (WWTPs) with site-specific permits (Figure 4). The City of Driggs plant is operating under permit #ID0020141 and has recently completed facility upgrades, so it is expected to fully meet its water quality obligations. The Driggs facility has a wasteload allocation for bacteria in this TMDL. The city of Rexburg WWTP is operating within specifications and does not pose a threat to the beneficial uses below its discharge location (#ID0023817). The Rexburg facility is not associated with any TMDL waters and has no wasteload allocations in this TMDL. There are no recommendations or requirements in this TMDL that suggest or indicate any necessary changes to the NPDES permits.

Other discharges within the subbasin involve construction, golf courses, and feedlots, but these do not have significant and continuous discharges to the waters of the Teton River subbasin and therefore are not included in this analysis. None of these secondary discharges have been found to significantly alter instream water quality. See Table 36 for a list of EPA-regulated dischargers.

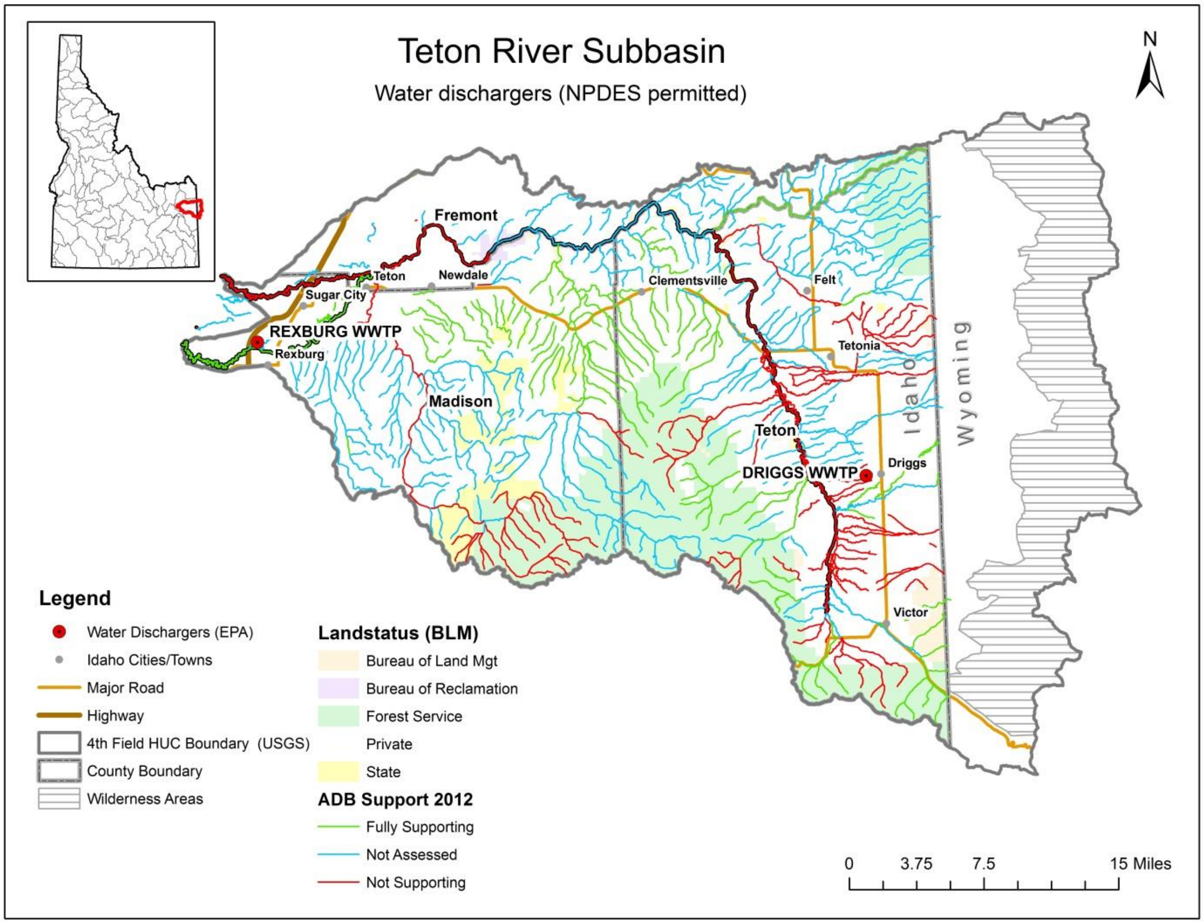

Figure 4. NPDES-permitted discharger locations in the Teton River subbasin.

3.2 Nonpoint Sources

A detailed discussion of nonpoint sources is provided in the 2003 TMDL (DEQ 2003a). In summary, all pollutants causing impairments are from nonpoint sources in this subbasin. Potential pollutants include sediment, bacteria, and temperature. Potential sources of these pollutants could include streambank modification and erosion, flow regulation and irrigation return water, road construction (disturbing less than 5 acres), pasture treatment, and mine tailings. Recreational activities may cause nonpoint sources of pollution where streambanks are becoming degraded by high use. Livestock grazing in riparian areas and erosion from roads and cultivated fields are common sources of excess sediment delivery to the streams. Destabilized streambanks also contribute to reducing riparian vegetation that would provide shade, which leads to excess solar load and increased instream water temperatures.

Primary nonpoint sources of pollution in the subbasin include the following:

- Streambanks and uplands contribute significant volumes of sediment to the streams and rivers within the subbasin.
- Heat loads from lack of shade on many portions of streams and rivers contribute to impairments to beneficial uses. The main stem Teton River at its headwaters at the confluence of Drake and Warm Creeks has significant ground water inputs that may be an additional temperature source, but it is not deemed as the causal factor leading to exceedances of the salmonid spawning temperature standard.
- Bacteria from domestic and wild animals (deer, moose, waterfowl) can be excessive. A study within the Woods Creek Complex found that avian/waterfowl sources alone can potentially exceed the bacteria standards in Idaho (Benjamin 2006).
- Multiple springs and wetlands exist within the basin. It is unknown if these are sources of pollutants (in particular heat additions), but a literature review indicated that wetlands can be either a sink or source of nutrients.

3.3 Pollutant Transport

There are two primary types of pollutant transport in the Teton River subbasin: direct and indirect inputs. The direct inputs include NPDES and Multi-Sector General Permit (MSGP) inputs from permitted discharges (based on loads and impairments, neither of these direct sources are updated or modified based on this TMDL); solar radiation; streambank erosion; and bacteria. The indirect pollutant transport is from locations not adjacent to the stream channel as pollutants are transported by water as surface flows (typically ephemeral or storm driven) but also wind and other natural phenomena.

4 Subbasin Assessment—Summary of Past and Present Pollution Control Efforts and Monitoring

A number of restoration, remediation, and rehabilitation projects have occurred in the Teton River subbasin since 2003. The stream water and habitat quality within the subbasin has been regularly monitored. This section discusses some of the restoration and water quality monitoring efforts along with the changing land use practices that have had positive effects on the water quality in the subbasin. All information contained in this section is summarized from larger datasets and documentation. Not all groups and agencies may be listed as participants in all projects as this document is not intended to be the definitive work on projects but serve as a summary source. Further details and information can be acquired from the managing agency or responsible group.

Multiple sources of water quality data have been made available for the development of this TMDL. The two primary sources have been the Friends of the Teton River (FTR) and the DEQ Idaho Falls Regional Office. The FTR has provided a long-term dataset (section 4.2), which includes multiple physical and chemical parameters. FTR was concerned that the nutrient concentrations in the Teton River were causing impairments to the beneficial uses. These concerns are detailed in the 2010 Integrated Report (DEQ 2011). In response to the 2010 Integrated Report comments, in 2012 DEQ developed a nutrient monitoring plan to examine the impacts of the nutrients of concern on the designated beneficial uses of the Teton River in the Teton River valley. Summary results are presented below. For more complete results and analysis, see Appendix D, which includes analysis of the FTR nutrient data. For inclusion in the 2012 Integrated Report (DEQ 2014), FTR presented journal papers and research linking nitrite concentrations (NO_2^{2-}) and trout survival, in particular YCT. However, there are no available nitrite data in the Teton River subbasin to support concerns detailed in the provided literature.

The DEQ temperature data collected in 2014 are presented in Appendix E.

The Assessment Database (ADB) used by DEQ contains a compilation of bioassessment data that have been collected statewide from 1994 through 2013. Analyzing the habitat condition and populations of macroinvertebrates and fish is the most efficient and cost-effective means of determining long-term water quality in streams. Diversity of species, existence of species with a low tolerance to water quality impairments, and size of populations are just a few of the measures that demonstrate support status of beneficial uses. See Barbour et al. (1999) for more information about bioassessment protocols that identify water quality characteristics.

4.1 Water Quality Pollution Control Projects

4.1.1 Nonpoint Source Program Grants (§319 Projects)

There were several disbursements from the Nonpoint Source Program grants (also known as §319 project funds) and the Idaho State Revolving Fund. DEQ has directed $522,495 to FTR for stream projects (Figure 5). Projects are described in the sections detailing FTRs restoration efforts.

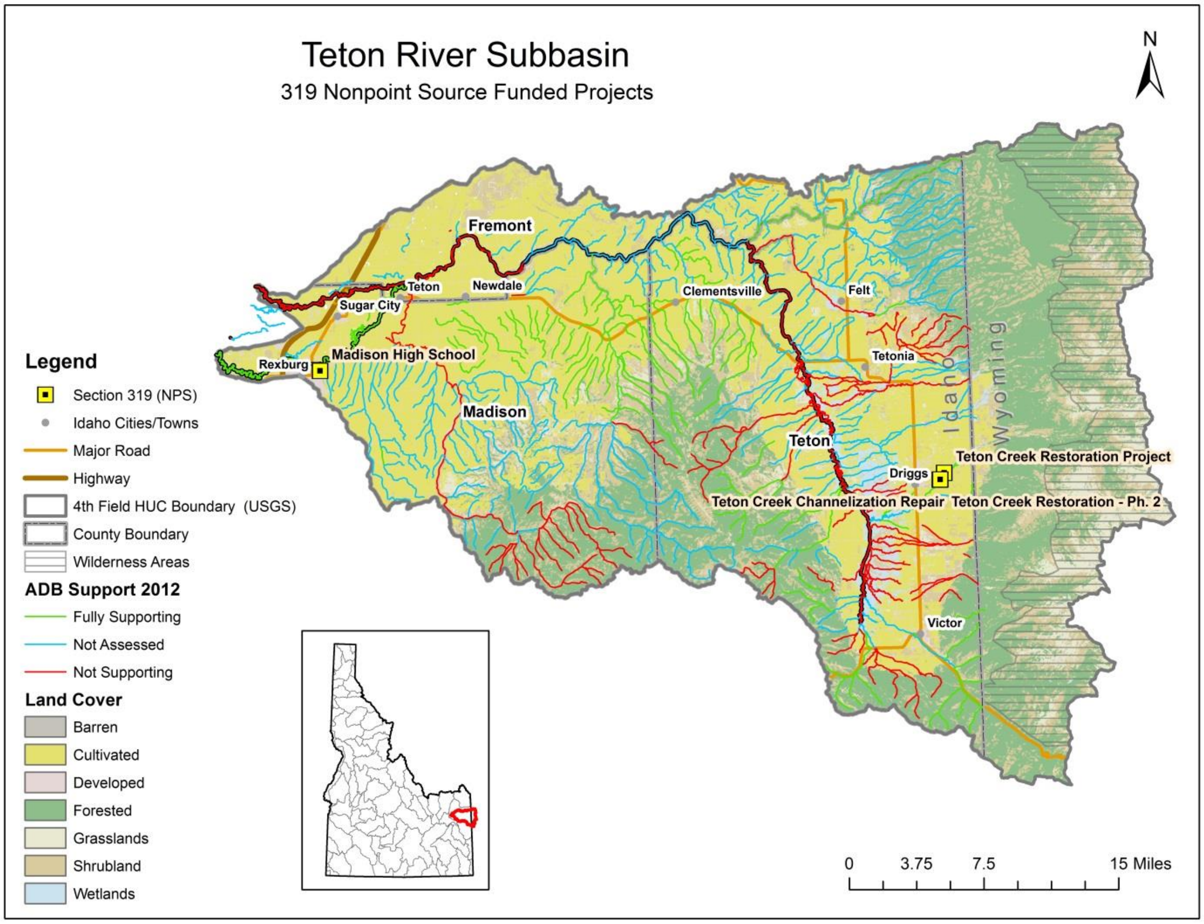

Figure 5. Location of Nonpoint Source Program grants and associated projects.

4.1.2 Caribou-Targhee National Forest

Multiple projects and data collection have occurred in the Teton River subbasin by the Caribou-Targhee National Forest personnel. Details can be obtained from their office or website. However, several projects are highlighted in this addendum to illustrate the ongoing efforts to improve water quality and habitat. For example, Horseshoe Creek and Packsaddle Creek had road improvements, including additions of gravel and drainage improvements. Bridges and open-bottom culverts were also added (Figure 6). Sediment issues in this area are often geologically controlled. Additional problems include ATV usage in sensitive and closed areas, which is causing increased damage to water quality; mitigation efforts are ongoing.

Figure 6. Open-channel bridge over Packsaddle Creek.

Projects from 2000 – 2005

The following project descriptions are sourced or summarized from USFS publications.

In summer 2000, Lee Mabey and project partners developed and implemented a survey to identify areas where beaver re-introduction or population enhancement could help improve riparian and hydrologic conditions. These improvements could have spin off benefits to riparian and aquatic dependent resources and enhance water quality.

This survey of 80 stream miles on tributaries of the Teton River was the next logical step after a recent watershed analysis indicated a decline in beaver populations in the analysis area.

The decrease in beaver populations has contributed to the decline of several stable, functioning streams. Beaver transplant compatibility matrices were completed for survey units on each stream to assess the feasibility of introducing beaver to an area based on social, biological/ecological, and habitat suitability parameters. Instream fine sediment was also measured. A report including findings and recommendations was prepared and distributed to Forest Service Districts and partners.

Project partners were DEQ and the Greater Yellowstone Coordinating Committee.

In cooperation with IDFG, beaver have since been re-introduced to North Twin Creek, Packsaddle Creek, Trail Creek, and the McRenolds Reservoir area. Certain areas have also been closed to trapping on National Forest lands.

The Trail Creek project, completed in 2003, restored fish passage to over 6 miles of the creek that had been blocked by an abandoned irrigation weir. This concrete weir was removed and the stream channel was roughened to facilitate upstream fish passage. Downstream of the weir, stream banks were stabilized and in-channel habitat was improved.

Beaver Reintroductions Continue in Teton Basin

In 2004, seven beavers were relocated to McRenolds Reservoir on the Teton Ranger District, including these young kits along with their parents. These beavers will help restore and maintain the wetland complex associated with the reservoir (Figure 7). During the recent drought years, the stream below the reservoir had all but dried up in the summer. With the wetter fall and the introduction of beaver back into the system, this lower reach should once again hold water year-round and be a boon to wildlife. The beaver in North Twin and Packsaddle Creeks appear to be enjoying their new homes, as the dams are enlarging and multiplying. Lodges are appearing, indicating the establishment of healthy, reproducing colonies. Several beavers were also released in Trail Creek in another attempt to establish colonies. Patterson Creek has also received approval from IDFG, and the local water users gave their support for reintroductions to occur in the future. However, given potential issues with irrigation infrastructure, beaver were never released into Patterson Creek.

Figure 7. Beavers waiting to be reintroduced.

Projects in 2006: Mail Cabin Creek

Years ago, Mail Cabin Creek jumped its banks and began flowing down the Mail Cabin Creek Road. The road has since been closed, but the erosion continued as the road had become the new stream. In 2006, streamflow was restored to its natural channel (Figure 8). A large tree and boulders were placed on the road redirecting the water to its natural channel and willows were planted. The access road into this area traveled across the front of a road fill for the Teton Pass highway and had been draining into Trail Creek along with its sediment load. This section was recontoured to improve drainage and reseeded. ATV use was also better managed. This project has decreased the sediment load in the stream and improved access for the fish to the upper watershed.

Figure 8. Mail Cabin Creek streambank redirection project.

Projects in 2007

Road-Related Sedimentation Reduced in Horseshoe Creek

In 2007, Horseshoe Creek, a tributary to the Teton River on the Teton Basin Ranger District, was improved with projects that reduced sedimentation, decreased stream channel erosion, and protected native Yellowstone cutthroat trout.

Roads are a major source of sediment into many Forest streams, as they are frequently adjacently located. The Horseshoe Creek project removed the water from the road surface before it caused erosion and sedimentation. This was done with the installation of cross-drains and rolling dips into the road surface. Rather than draining the road run-off directly into the stream, it was diverted to vegetated areas where it could be filtered of sediment prior to entering streams. Visual monitoring after rain events indicated the treatments reduced sediment delivery to streams and increased stream clarity.

In addition to the road drainage work, a rock structure was constructed in Horseshoe Creek to stop upstream channel erosion at an old dam site and block the upstream migration of non-native trout, protecting a population of native Yellowstone cutthroat trout located upstream.

This work was funded in partnership with the Idaho Department of Environmental Quality. In the coming year, two undersized culverts will be replaced.

This rock structure was constructed in Horseshoe Creek to exclude non-native fish from the project area and stop head-cutting.

Habitat Improved in Horseshoe Creek

Native Yellowstone cutthroat trout in Horseshoe Creek have been impacted for decades by roads and invading non-native fish. Horseshoe Creek is a tributary to the Teton River, a basin with limited remaining populations of native cutthroat trout. The Horseshoe Creek Project is a multiple year effort to benefit native fish and their habitat by reconnecting stream segments and replacing impassable culverts, decreasing sedimentation by improving road drainage and surfacing, and decreasing the potential of non-native fish colonization by constructing barriers to upstream migration. In 2008, an undersized, barrier culvert was replaced with a bottomless arch by the Forest Road Crew. This project is a partnership between the Forest, U.S. Fish and Wildlife Service, and Idaho Department of Environmental Quality.

Horseshoe Creek culvert before replacement.

Crossing after culvert replacement.

Projects in 2011: Maytag Horseshoe Creek

A culvert on the North Fork of Horseshoe Creek was replaced with a 15-foot bridge, correcting road, fisheries, and flow needs during late fall 2011 (Figure 9).

Partners included Teton County Road and Bridge Crew, USFWS, and Trout Unlimited.

Figure 9. Culvert before. **Bridge after.**

Projects in 2013–2014

Darby Creek Trailhead Relocation FS RD #012

This project moved the trailhead outside of the aquatic influence zone (AIZ), improving buffer distances. The project involved installing a new trail bridge to replace an undersized structure at the end of its lifespan, moving the trailhead 0.25 miles down the road, obliterating 0.25 miles of road, obliterating the existing trailhead reclaiming the historical floodplain and terrace, constructing 0.25 miles of new trail, and restoring 200 feet of stream channel. The new trailhead incorporated a turnaround, provides for separate parking areas for trailers, and will accommodate more parking within the actual trailhead than the previous site (Figure 10–Figure 12).

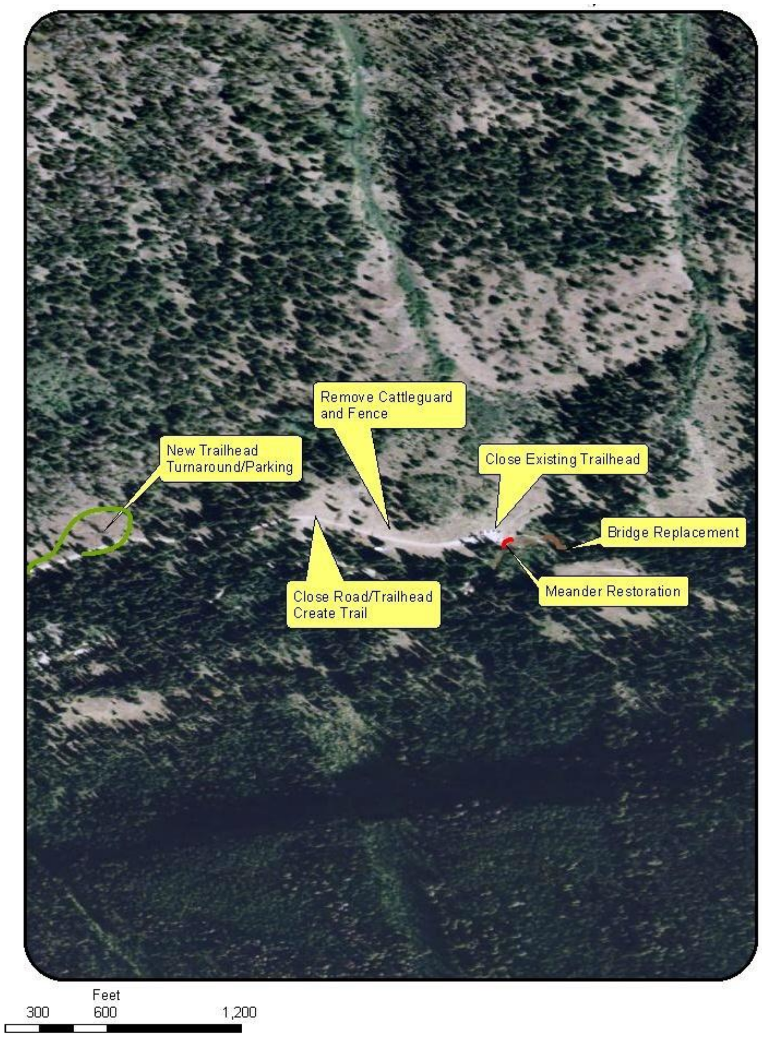

Figure 10. Aerial photo depicting locations of remediation actions.

Figure 11. Existing bridge constricted stream and needed upgrading.

New bridge is an engineered, laminated beam construction, spanning the width of the channel.

Figure 12. Existing trailhead was within the AIZ with an eroding meander bend within a few feet of the parking area.

Post-construction the channel profile was narrowed by re-establishing a proper riffle pool complex, and the eroding meander was sloped and reinforced using whole trees.

4.1.3 Friends of the Teton River

Stream Habitat Restoration

Much of the following material was adapted from the FTR website (*www.tetonwater.org*). This compilation is an abbreviated summary of the restoration work and is specific to the most recent work (Figure 13). Complete information is available from the website or by contacting the FTR office. A complete list of partners involved in these projects is available online. Below is a summary of projects followed by a selection of short project descriptions (Table 11 and Table 12).

FTR started the stream restoration program in 2003 to improve fish populations, aquatic ecosystems, and water quality and to reduce flooding risk and property loss. FTR uses a holistic approach to restoration that is part of a collaborative process involving project stakeholders. FTR uses a variety of innovative bioengineering techniques to stabilize streambanks and channels designed to meet specific project goals. By the end of 2009, FTR had restored nearly 3 miles of stream and re-vegetated over 9 acres of stream corridor with native vegetation. The restoration work has brought over $1 million to Teton Valley.

FTR is presently undertaking the Teton Creek Restoration Project, which includes a stream section adjacent to Aspen Pointe, The Aspens, and The Willows subdivisions. This project started in 2006 when a group of stakeholders came to FTR asking for help stabilizing a portion of Teton Creek that had been dredged and channelized for 24 years. FTR worked with the stakeholders to develop an innovative design that protects property while supporting a healthy aquatic ecosystem. The project, budgeted at $3 million, will be completed in 2016 and involves rebuilding over 1 mile of stream channel.

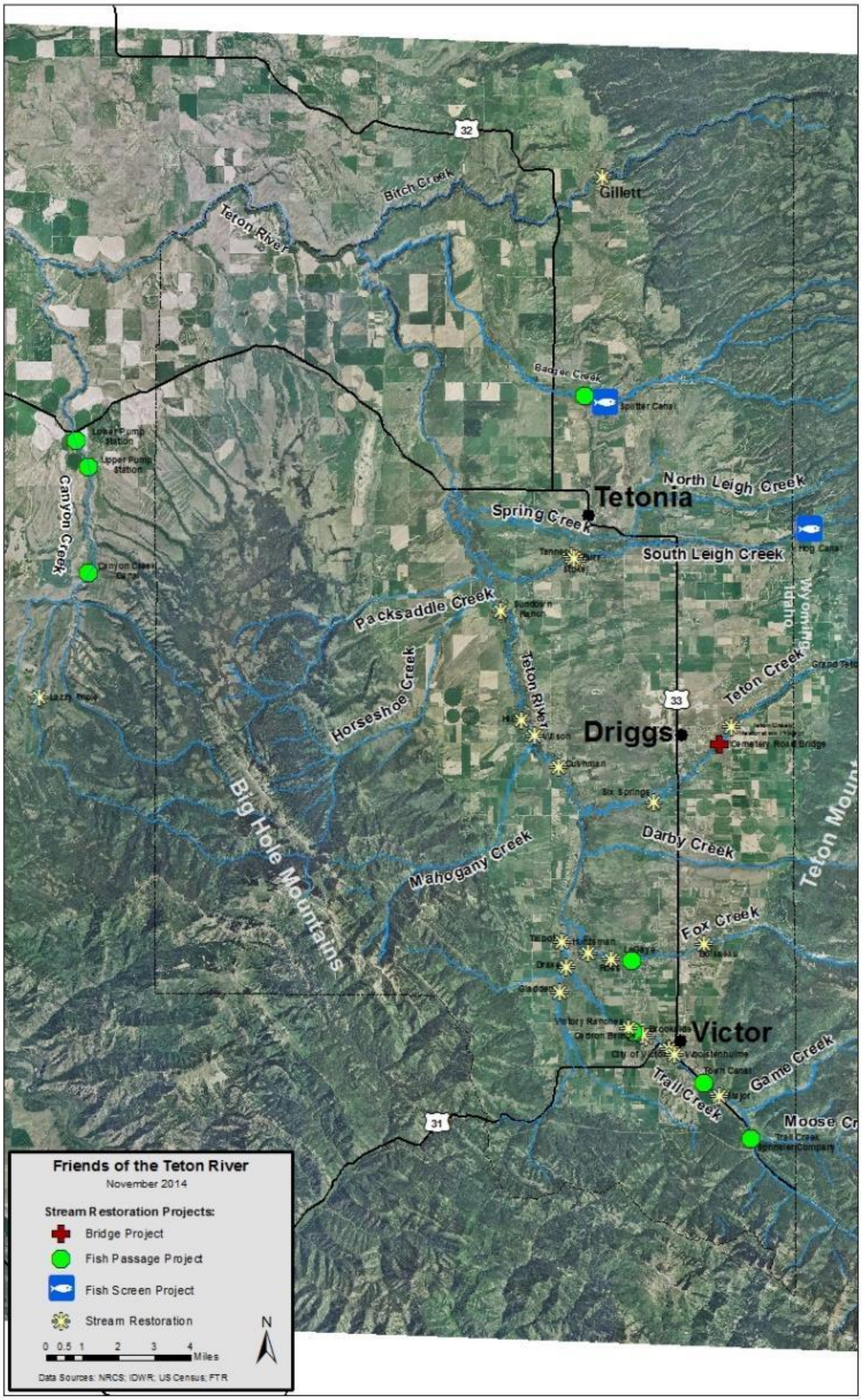

Figure 13. FTR stream restoration project locations as of November 2014.

Table 11. FTR stream restoration project stats, 2007–2014 projects.

Stream	Site #	Project Date	Sediment Reduction (tons/yr)	Stream Bank Length (ft)	Area Revegetated (ft^2)	Planting Material					
						Mature Willow Clumps	Willow Poles	Willows 5-gal	Other Woody 5-gal[a]	Cottonwood 5-gal	Grass Seeded (ft^2)
Trail Creek		July 2007		150	600		400	35	35		600
Trail Creek		July 2007		662	4,634	50	2,000				
Trail Creek		July 2007		90	500	7	250				
Trail Creek		October 2007		255	2,000	20	750				
Trail Creek	Phase 1	October 2010	572	4,400	50,000	1,000	4,000				25,000
Trail Creek		October 2008		400	4,200	40	1,800				44,750
Fox Creek		October 2008		35	200	3	75				
Fox Creek	Culvert	October 2008		30							
Fox Creek		October 2008		1,485	10,395	100	3,900				
Fox Creek		April 2009		300	2,000		3,500				
South Leigh		October 2007		720	3,600	40	2,000				
South Leigh		October 2007		182	910	12	500				
South Leigh		October 2007		449	2,245	30	5,000				
Teton Creek		July 2007		600	20,000	250		400	400	400	20,000
Teton Creek	Phase 1	November 2009		2,080	40,000	500	1,338	10	83	82	40,000
Teton Creek	Phase 2	December 2010		2,300							
Teton Creek	Phase 3	December 2014	2,800	7,820	204,000	1,065	9,000				100,000
Teton River		September 2008		250	1,250	20	750				
Bitch Creek		October 2012		545	2,180	55					
Canyon Creek		December 2013	126	1,400	4,200	140					
Totals:			**3,498**	**24,153**	**352,914**	**3,332**	**35,263**	**445**	**518**	**482**	**230,350**
Totals (acres, miles):				**4.57**	**8.10**						**5.29**

[a] Douglas hawthorn, choke cherry, alder

Table 12. FTR stream restoration project stats, 2003–2006 projects.

Stream	Project Date	Stream Bank Length (ft)	Area Re-vegetated (ft^2)	Planting Material								
				Mature Willow Clumps	Willow Poles	Willows 5-gal	Willows 1-gal	Other Woody 5-gal[a]	Cottonwood 5-gal	Other Trees 5-gal[b]	Shrubs 1-gal[c]	Grass Seeded (ft^2)
Teton River	Apr 2003	230	6,900		690	46						5,520
Teton River	Apr 2003	235	7,050		705	47						5,640
Teton River	Apr 2003	1,090	32,700		3,270	218						29,430
Teton River	Apr 2003	350	10,500		1,050	70						8,400
Teton River	Dec 2006	350	2,100	27								
Fox Creek	Nov 2003	2,600	156,000	20	4,625	32		9	4	22		132,600
Six Springs	Oct 2005	1,730	26,400			330		50				
Trail Creek	Sep 2006	250	3,000			40	20				120	3,000
Trail Creek	Aug 2006		2,000			26		20	10		20	2,000
Trail Creek	Aug 2006		200			10						200
Totals		**6,835**	**246,850**	**47**	**10,340**	**819**	**20**	**79**	**14**	**22**	**140**	**186,790**
Totals (miles, acres):		**1.29**	**5.67**									**4.29**

[a] Douglas hawthorn, choke cherry, alder
[b] Aspen, birch
[c] Potentilla, currant, mountain snowberry

Teton River Project

The bank on the Teton River in the restored reach was previously lined with rip-rap to prevent erosion (Figure 14). This project was designed to remove all of the rip-rap except for rock along the toe of the bank. The portion of the bank previously covered in rip-rap was stabilized using bioengineering techniques including rootwads, willow clumps, erosion control fabric, a soil lift system, willow bundles, and willow poles. The project was completed in September 2008.

Figure 14. Streambank restoration along the Teton River.

Aspen Pointe, The Aspens, and The Willows Restoration Project

The Teton Creek Restoration Project area extends for over a mile upstream from the Cemetery Road Bridge and includes the Aspen Pointe, Aspens, and Willows subdivisions. From 1983 to 2004, approximately 4,000 linear feet of the project area was channelized by the developer to protect subdivisions from flood events. The developer closed off side-channels; lowered the streambed 4–8 feet, destabilizing the channel and increasing the risk of flooding; and caused substantial property loss. Lowering the streambed caused streambanks and the upstream streambed to collapse, which subsequently started a headcut that migrated upstream approximately 2,000 linear feet. The wide, deep channel lacked fish habitat, could not effectively dissipate stream energy, and did not allow floodwaters to access the floodplain, which is critical for riparian vegetation health. An estimated 120,000 cubic yards of sediment has been displaced from the project area, much of which has been transported downstream causing severe bank erosion and channel destabilization and increasing downstream flooding risks for over 2.5 miles.

The project started in 2006 when FTR formed the Teton Creek Subwatershed Committee (TCSC) comprised of landowners, developers, and local, regional, and federal government agencies. The intent of FTR and the TCSC has been to develop a holistic approach to improve conditions on Teton Creek based on collaboration and community participation. The total project cost is estimated at $3 million, which includes construction of an inset floodplain along the 6,100-foot project length and new Cemetery Road Bridge. Project construction was scheduled to occur in phases over several years and is dependent on funding. The majority of the project, Phases 1–3, were completed in 2013. The last phase will be completed in 2016 (Figure 15).

Figure 15. Streambank restoration along Teton Creek.

The bridge along Cemetery Road was replaced in fall 2009 as a part of the Aspen Pointe, Aspens, and Willows Restoration Project. The old bridge built in the mid-1970s was only capable of conveying just over half of a large flood event (approximately 1,200 cubic feet per second [cfs]), meaning that a large flood event could potentially cause the bridge to fail and flood Driggs. The new bridge is constructed out of three spans that can convey a large flood event (approximately 2,050 cfs). The new bridge is significantly wider, improving public safety. This project was completed in October 2009.

Victory Ranches Phase 1

The project area along Trail Creek was channelized in the 1970s and is currently not functioning as a productive, stable trout stream (Figure 16). The channelization work severely compromised natural channel process, fish and wildlife habitat, and riparian vegetation. The channel lost the ability to effectively dissipate stream energy during flood events, which increased stream energy and erosive forces causing significant damage to Trail Creek for miles downstream of the project area. This was Phase 1 of a multi-year, multi-phase project.

The project restored valuable fish and wildlife habitat and channel characteristics necessary for a healthy, functioning trout stream. Approximately 2,150 linear feet of channel were reshaped and stabilized using 4 rock weirs and 15 constructed riffles. Approximately 4,300 feet of streambanks were stabilized using bioengineering streambank stabilization techniques including willow clumps, vertical bundles, and willow poles. Inset floodplain benches were added and planted with native vegetation to dissipate flood energy, help capture sediment, and enhance riparian vegetation. Sinuosity was enhanced by reshaping stream bends. The project was completed in November 2010. Partners included Travis Thompson (Victory Ranches LLC), Aqua Terra Restoration, the Natural Resources Conservation Service, Trout Unlimited, USFWS, North Fork Native Plants, and Silver Star Communications.

Figure 16. Streambank restoration along Trail Creek.

Boisseau Project

This project restored 300 feet of rapidly eroding streambanks on Fox Creek. The streambanks eroded laterally up to 4 feet in 2 years. A home and associated infrastructure were at risk due to the rapid erosion. The eroding streambanks were stabilized using bioengineering techniques including brush mattresses, pole and clump plantings, fascines, and rock barbs. Rock, brush mattress, and erosion control fabric was used to stabilize the eroding bank near the home. Banks will be irrigated with an irrigation system until vegetation has reached a self-sustaining level. The project was completed in April 2009. Partners included Julie Boisseau, Aqua Terra Restoration, and the USFWS.

Fish Passage Projects with FTR Involvement

Town Canal Fish Passage Project

Prior to this project, the Town Canal diversion included a channel-spanning concrete weir with a pool on the downstream side of the weir (Figure 17). During low flow levels, the weir created a 2-foot vertical drop that inhibited fish passage. As water levels on Trail Creek dropped in mid-summer, this vertical barrier increased to 4 feet, which stranded fish in the pool downstream of the weir. These stranded fish would perish in the pool when Trail Creek was dewatered in late summer. During project construction, which occurred when Trail Creek was nearly dry, FTR found approximately 40 fish stranded in the pool, including YCT. The project was designed to improve fish passage at all flow levels, to prevent entrapment of fish in the pool when Trail Creek is dewatered, and to repair the undermined portion of the diversion weir.

To accomplish project goals, FTR installed an A-frame vortex weir positioned in a stepped configuration downstream of the weir. The A-frame weir was designed to create a series of pools, with the water surface of the uppermost pool at the approximate elevation of the top of the diversion weir, thereby eliminating the drop. Large rock fill was placed in the undermined section of the diversion weir to further stabilize the structure. Project partners included the Idaho Department of Fish and Game, On-the-Rocks Aggregate, and Trail Creek Nursery.

Figure 17. Check dam and fish passage improvements on Trail Creek.

Fish Ladder Improvement Project

This project involved several improvements to an existing fish ladder located on the main Trail Creek Sprinkler Irrigation Company (TCSIC) irrigation diversion located on a section of Trail Creek southeast of Victor, Idaho (Figure 18). The original entrance pool to the fish ladder washed away and needed to be replaced. Without an entrance pool, the fish ladder exits into a shallow section of stream at velocities that are significantly higher than recommended. FTR also measured higher-than-recommended velocities within the ladder itself.

One component of the project was designed to construct a new entrance pool large enough to submerge the first fish ladder plate, thereby significantly reducing velocities at the ladder entrance. The other component of the project was to lower velocities within the ladder by replacing panels that had been removed and installing a new orifice plate at the upstream end of the ladder. A fish trap was installed in 2006 at the upstream end of the fish ladder. Numerous improvements were made to the trap in 2007 and 2008. In July 2008, FTR found fish in the trap indicating that the fish ladder was working. Project partners included IDFG, USFS, On-the-Rocks Aggregate, Trail Creek Nursery, and Majestic Mountain Metal.

Figure 18. Fish ladder improvements on Trail Creek.

Fish Screen Development with FTR Involvement

Hog Canal Fish Screen Project

South Leigh Creek is an important stream for YCT, both in terms of productivity and recruitment for the upper Teton River. South Leigh Creek has the second highest numbers of YCT of all the upper Teton River tributaries and is one of only four upper Teton River tributaries to contain YCT without the presence of nonnative trout. FTR electrofished the Hog Canal and estimated that approximately 100 native YCT, or 5% of the upper South Leigh Creek YCT population, become entrained in the canal annually and perish when the canal headgates are shut off. The entrainment potential of Hog Canal was considered to be very high due to relatively high diverted flows (up to 90 cfs) and due to the quality of fish habitat found in the canal. The old headgates were damaged by debris and leaked 2–9 cfs when closed.

This project retrofitted the existing diversion structure with Hydrolox fish screens, a bypass pipe, new headgates, and new trash racks. The rotating fish screens allow the irrigators to receive their water, while preventing native YCT from entering the canal. The new headgates will keep more water in South Leigh Creek, thereby increasing flows to the benefit of the riparian vegetation, fish, wildlife, and stream function. The new headgates allow for tighter control and can be easily locked. Project partners included Boyd Smith, Teton Conservation District (Wyoming), Creative Energies, USFWS, National Fish and Wildlife Foundation, Jackson Hole One Fly Foundation, Owen-PC Construction, Hydrolox Screens, and Majestic Mountain Metal.

Splitter Canal Fish Screen Project

Badger Creek is one of only four upper Teton River tributaries that contain YCT without the presence of nonnative species. The Splitter Canal Project benefited watershed health by preventing further entrainment of YCT into the canal and improving flows on Badger Creek. The old diversion structure, called the Splitter, was dynamited years ago to open up debris-jammed headgates and was no longer functioning. FTR removed the nonfunctioning structure and replaced it with a new structure, new headgates, a bypass pipe, and Hydrolox fish screens. The rotating fish screens allow the irrigators to receive their water while preventing native YCT from entering the canal. Prior to the project, approximately 5–10% of the upper Badger Creek YCT population was entrained and stranded in the canal annually. The new structure also improves flows in the creek by providing water regulators with controllable headgates and accurate staff gage readings. Project partners included IDFG, National Fish and Wildlife Foundation, Creative Energies, Jackson Hole One Fly Foundation, Owen-PC Construction, Hydrolox Screens, Trail Creek Nursery, and Majestic Mountain Metal.

Water Reconnections

FTR has had an extensive role in the long-term water quality monitoring, instream flow enhancement, and restoration in the Teton River subbasin. Many recent projects have been directed at issues associated with habitat conditions necessary for YCT, which had been examined for inclusion on the endangered and threatened species list (see section 1.5) but was determined not meeting the listing requirements at that time (Federal Register 2006) and remains a species of interest and conservation need. In the 2003 TMDL, Spring Creek and South Leigh Creek had TMDLs developed for sediment and temperature. The temperature listings have been updated using the PNV methods, which are discussed in more detail in section 5.1. Recent projects and a short summary describing FTR’s efforts in the Teton River subbasin are also provided in other portions of section 4.1.3.

Spring Creek

FTR worked with four water right holders along Spring Creek to lease a total of 4.35 cfs of water rights, committing those water rights instream for the benefit of YCT migration, holding, and outmigration to the Teton River. Each of the water rights was historically diverted at the Tetonia Canal. The current lease term for each water right is 5 years (2013–2017). The water rights were leased into the Idaho Water Supply Bank and then rented by the Idaho Water Resources Board (IWRB) for delivery to the Teton River minimum streamflow right (which begins at Harrops Bridge). In addition to the fisheries benefits, Spring Creek is §303(d) listed for sediment, flow alteration, and temperature from the Wyoming state line to the Teton River (12.6 miles), and it is expected that these water transactions will begin to address water quality constraints.

Per Morgan Case (IDWR, personal communication, July 2014), Spring Creek has four water leases adding 1.85 cfs to Spring Creek from 2013–2017. These numbers are slightly different from the FTR numbers as they are based on a different set of calculations and assumptions of delivery.

South Leigh Creek

FTR worked with two water right holders on South Leigh Creek to increase streamflows, as current irrigation withdraws and the natural stream hydrology result in the annual dewatering of South Leigh Creek. One water right holder has two water rights, which cumulatively allow for the diversion of 0.11 cfs. These water rights have been committed to an instream flow purpose for a period of 5 years. The water rights were leased into the Idaho Water Supply Bank and then rented by the IWRB for delivery to the Teton River minimum streamflow water right (which begins at Harrops Bridge). The second water right holder worked with FTR to secure approximately 1 cfs of additional water instream. The transaction opened up additional habitat for the resident YCT population that utilizes the perennial reaches of South Leigh Creek near the USFS boundary. As a result of the transaction, streamflow was maintained in South Leigh Creek from the stream’s headwaters to the Desert Canal diversion throughout the entire irrigation season. This increased habitat, streamflow, and subsequent reconnection during the summer of 2014 led to the first fluvial YCT captured in South Leigh Creek upstream of the Desert Canal diversion in many years. This YCT mainstem–South Leigh Creek interaction indicates that the transaction has had a positive impact on the YCT fishery in South Leigh Creek.

The described water transactions are part of a larger effort to improve stream function and prevent fish entrainment. FTR alone has conducted three stream restoration projects on South Leigh Creek, restoring and stabilizing over 1,350 feet of stream and re-vegetating over 6,755 square feet of streambank. Substantial stream restoration work has also been conducted by private landowners. Additionally, FTR worked with irrigators to rebuild the largest diversion structure on South Leigh Creek, the Hog Canal diversion (located in Wyoming). The rebuild not only incorporated modern diversion works but included solar-operated fish screens to prevent fish from being entrained in the canal. Building from the success of the Hog Canal project, FTR and Biota Engineering worked with irrigators to complete a similar project at the Desert Canal diversion in 2015.

4.1.4 Natural Resources Conservation Service

The NRCS has been active in the Teton River subbasin promoting changes in land management, with one of the results leading to improved water quality (L. Markegard, personal communication, December 2014). Since the 2003 TMDLs, additional lands have been added to the Conservation Reserve Program, where farmers enrolled in the program remove environmentally sensitive land from agricultural production. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat.

In addition to those Conservation Reserve Program efforts, the NRCS has also been active in multiple projects, such as revegetation, streambank stabilization, and habitat restoration throughout the subbasin. Other land use changes include improved irrigation management, typically with the increased use of sprinkler systems combined with tillage methods to limit soil loss. Along the Teton River main stem, the NRCS has worked with landowners to stabilize and revegetate the streambanks, typically using willows and wetland vegetation, as well as riparian fencing as used upstream of Highway 33. Incremental but continuous improvements have occurred within the Teton River subbasin.

4.1.5 US Bureau of Reclamation

Per J. Bountry (personal communication, October 2014), the USBR studied the river section upstream of the dam failure that was affected by the rapid reservoir drawdown during failure. They found that rapids had increased in size due to landslide material falling into the river during the failure. The new rapids created deeper pools and more backwater. Some of the upstream-most pools were partially filling with sediment and they predicted that trend would continue downstream as more sediment load continued to be delivered from upstream. The pools looked like they were filling to a new "equilibrium."

Complete study details are available in *Geomorphology and River Hydraulics of the Teton River Upstream of Teton Dam Teton River, Idaho* (Randle et al. 2000).

Other projects and data collection efforts by the USBR have occurred and details are available from the Snake River Area Office.

4.1.6 US Bureau of Land Management

TheBLM is a minor landowner in the Teton River subbasin, with approximately 2% of the area under its management. Many of those acres are widely dispersed across the subbasin. Grazing lands and rights are regularly monitored and updated, while other locations are managed to minimize impacts to the resource and nearby locations (D. Kotansky, personal communication, December 2014).

BLM does not have active grazing allotments on the Teton River, Badger Creek as it confluences with the Teton River, Bitch Creek as it confluences with the Teton River, or Canyon Creek sections. These locations and streams are not grazed on BLM-administered lands. An upper reach of Bitch Creek is grazed on public lands further upstream of the Teton River confluence. BLM manages the remaining public lands in the subbasin that are grazed through a 10-year grazing permit renewal process that includes a rangeland health standards and guidelines allotment assessment. This overall assessment evaluates soils, vegetation, wildlife and fish habitat, and streams and riparian-wetland areas. Riparian-wetland areas, including streams, are monitored by the riparian area proper functioning condition (PFC) method, which evaluates riparian-wetland vegetation, soils, streambanks, channel, and floodplain. Other riparian monitoring tools include stubble height, which measures the height of the riparian-wetland vegetation during and after grazing.

BLM managed a fuels reduction project that involved a selective forest cut for about 4–5 years beginning around 2008 on a small, unnamed stream south of Fox Creek near Victor, Idaho. The goals were to reduce the density of the overstory and release some aspen stands, encouraging more aspen growth and density. This project used mostly nonmechanized skidding (horse skidding) techniques, resulting in less surface disturbance to approximately 150 acres.

4.2 Water Quality Monitoring

Data sources used in developing this document are presented in Appendix F.

4.2.1 Temperature

Temperature logger data were collected by DEQ in 2014 and were used in developing TMDLs for temperature (Figure 19). Four temperature data loggers were deployed in the main stem Teton River; each location was found to have exceedances of the salmonid spawning temperature standards. Thermographs and exceedance tables are contained in Appendix E. Salmonid spawning dates are based in part on the recommendations from the *Water Body Assessment Guidance* (Grafe et al. 2002) and *Teton River Investigations, Part III: Fish Movements and Life History 25 Years after Teton Dam* (Schrader and Jones 2004), which have complimentary spawning dates with the spawning period ending in mid-July.

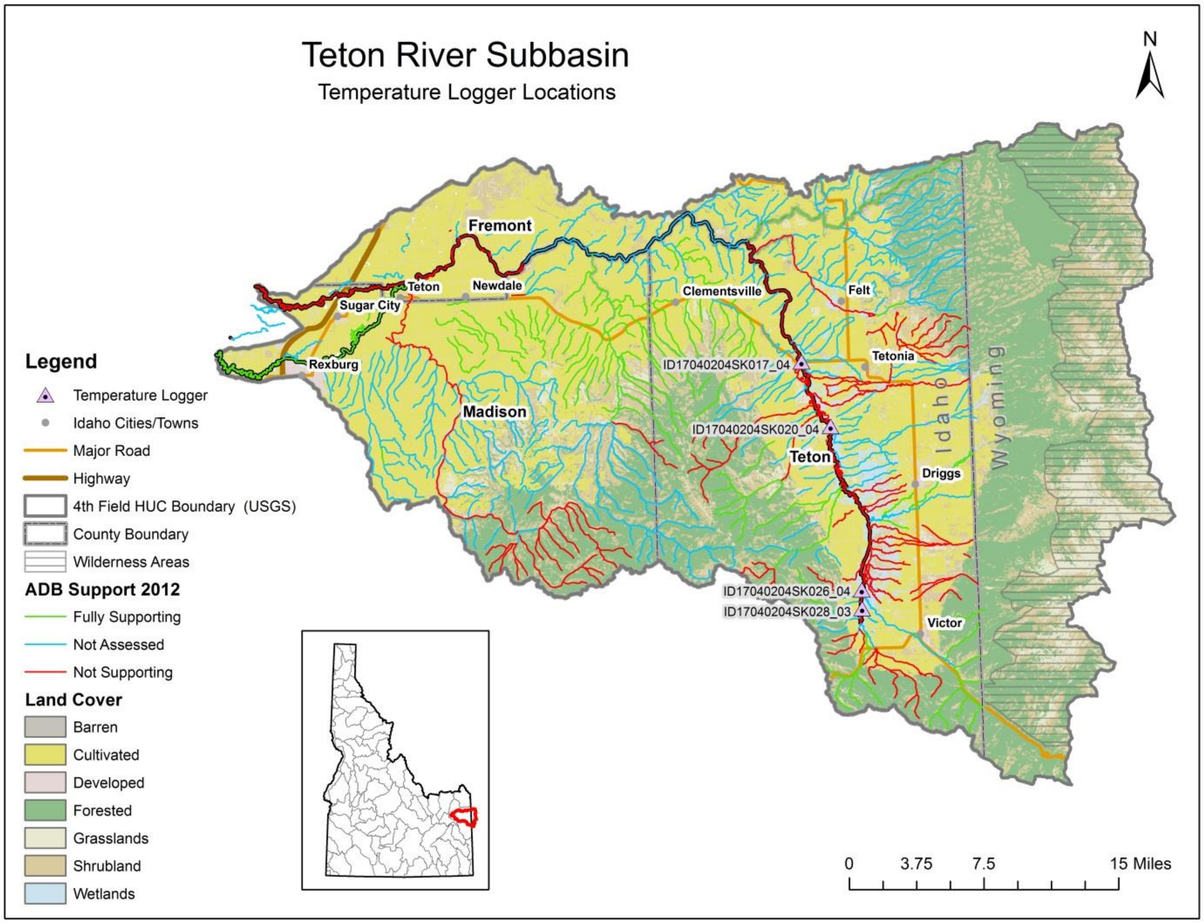

Figure 19. Temperature logger deployment locations.

4.2.2 Sediment, Riparia, and Streambanks

DEQ sediment monitoring is detailed in Appendix C. This monitoring included streambank erosion inventories and observations relevant to maintaining and updating current TMDLs. New and updated TMDLs are detailed in section 5.2, with datasheets and analysis in Appendix C.

4.2.3 Bacteria

The 2011 bacteria geometric mean data summarized in section 5.3.3 are presented in full in Appendix G along with analysis and interpretation. There are 3 AUs with bacteria-based TMDLs developed in this document (section 5.3). Differences in the Warm Creek locations, since there are two Category 5 listed Warm Creeks, are clarified by including the watershed name (Figure 20).

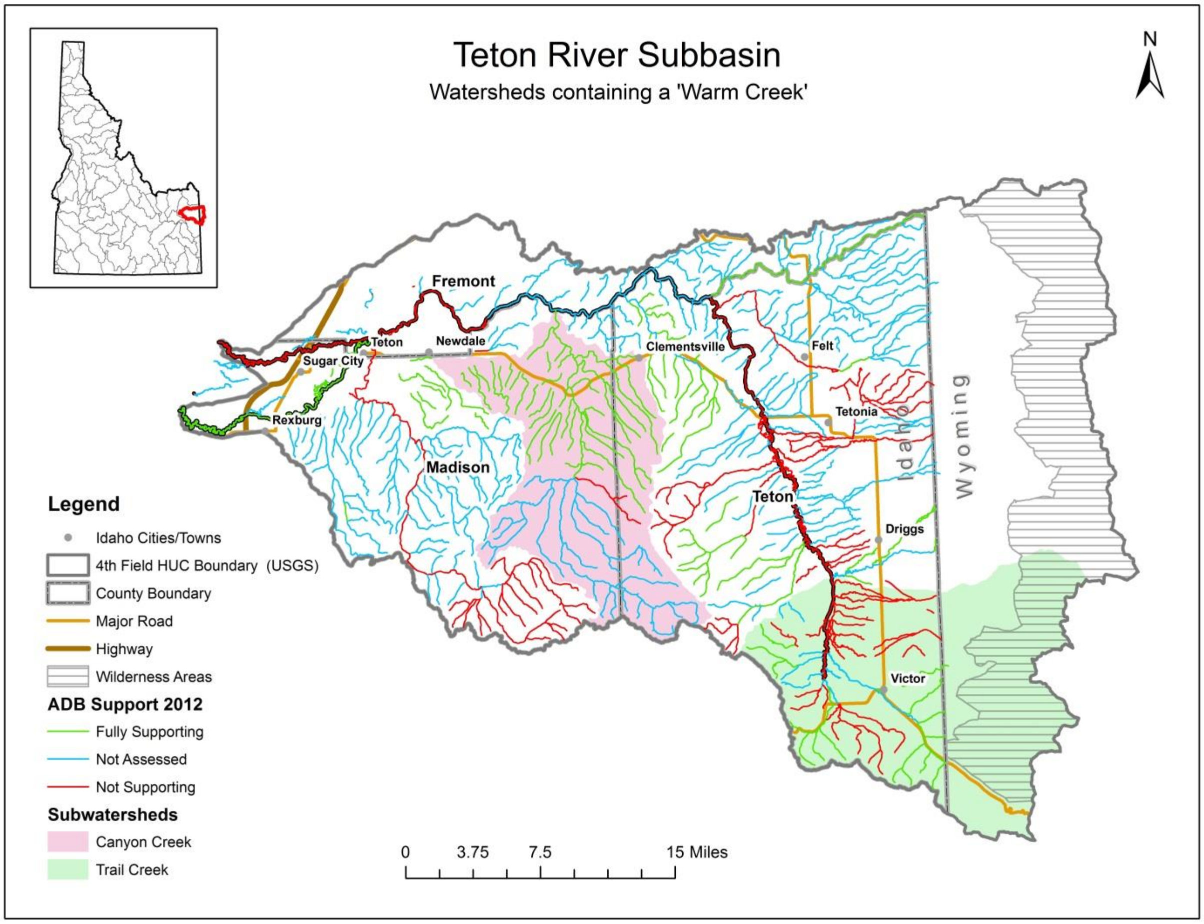

Figure 20. Location of watersheds containing a Warm Creek. Warm Creek AU SK011_02 (Canyon Creek watershed) is shaded in pink; Warm Creek AU SK034_02 (Trail Creek watershed) is shade in green.

4.2.4 River Monitoring

River metrics similar to the wadeable BURP data are available in Appendix H and are discussed in context of the nutrient monitoring and beneficial use attainment in the upper Teton River in Appendix I. River BURP data indicate that in the 4 AUs of the main stem upper Teton River, all metrics are meeting beneficial uses based on the fish, habitat, and macroinvertebrate monitoring. The known sediment exceedances of the narrative criteria and the measured temperature exceedances of the salmonid spawning criteria are known stressors and discussed in section 5.

River monitoring has occurred in six locations since 1998 (Figure 21). The 1998 monitoring used different protocols from the 2012 data and therefore direct comparisons and metric calculations are not possible. However, 2012 data indicated that the calculated fish, macroinvertebrate, and habitat index scores were fully supporting the designated beneficial uses (see Appendix I for details).

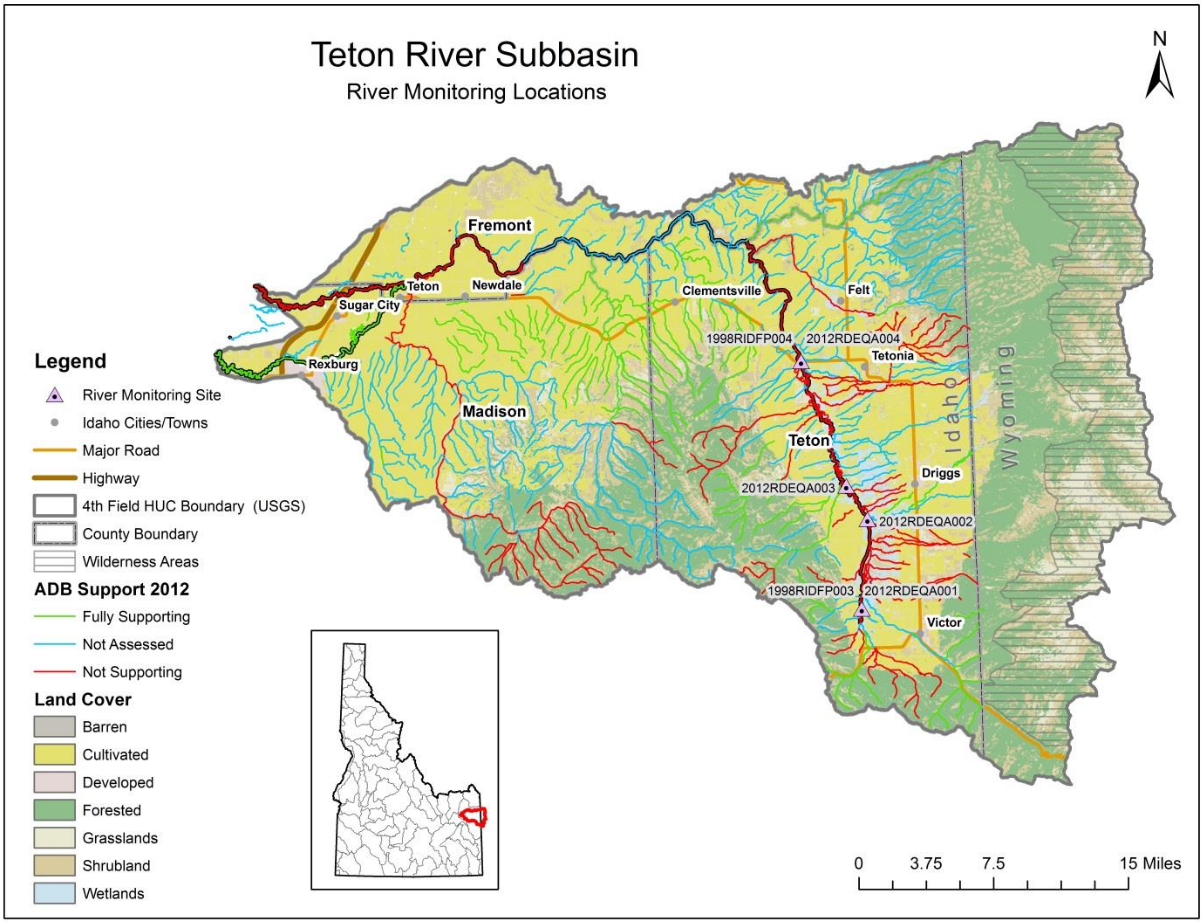

Figure 21. River monitoring locations, 1998 and 2012.

4.2.5 Friends of the Teton River

FTR have been regularly monitoring water quality in the Teton River subbasin since 2002. Water quality data are collected 2–4 times per year at multiple locations within the subbasin, including the Wyoming portion of the subbasin. There are 12 sample locations (see bullet list below and Figure 22.) FTR laboratory information and detection limits are listed in Table 13. FTR data are summarized in Appendix D and analyses of the nutrient data are included in Appendix I. Raw data, maps, and laboratory information were supplied by FTR; data were summarized by DEQ staff. The detection limit value was used in the descriptive statistics summarization; no attempt was made to estimate a value below that detection limit based on distribution (i.e., normally distributed).

Site Locations

- DAR = Darby Creek (in Wyoming)
- FISH = Fish Creek
- FOX 1 = Fox Creek (downstream)
- FOX 2 = Fox Creek (upstream, in Wyoming)
- SIX = Six Springs
- TC2 = Teton Creek (in Wyoming)

- TR1 = Teton River (below confluence Warm and Drake Creeks)
- TR2 = Teton River (South Bates Road)
- TR3 = Teton River (Bates Road)
- TR4 = Teton River (Highway 33)
- WARM = Warm Creek
- WOODS = Woods Creek

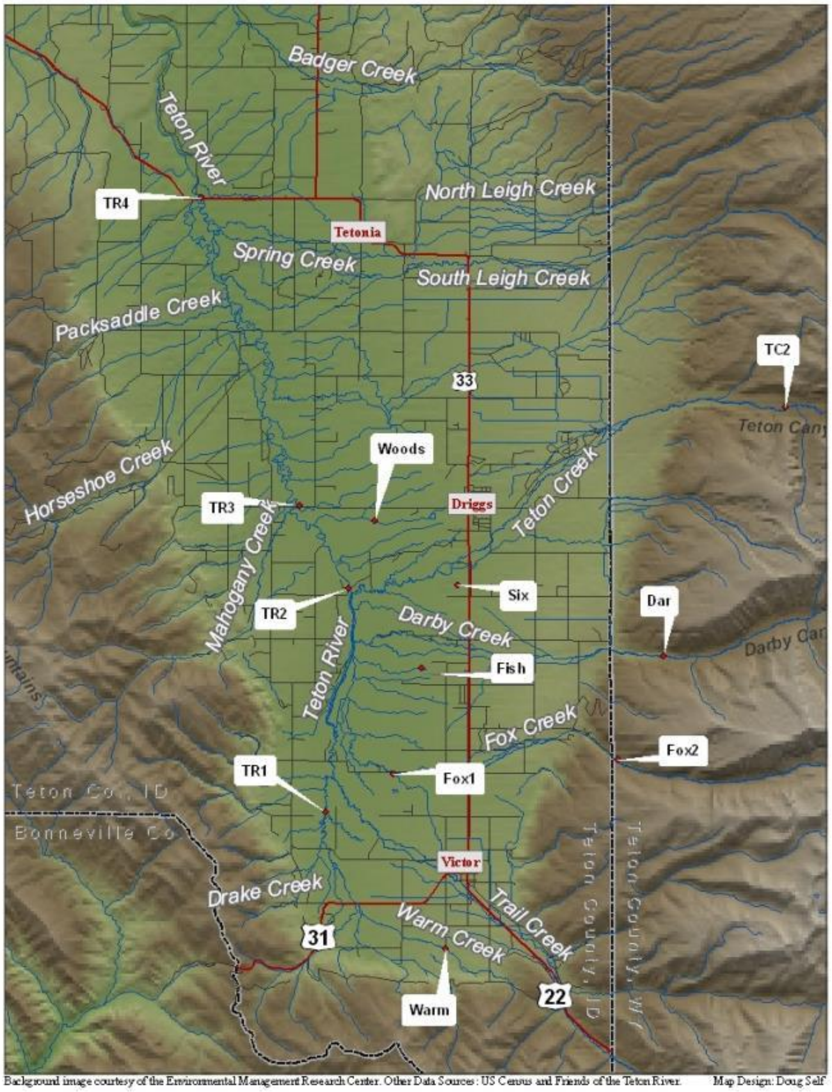

Figure 22. FTR map of sample locations within the upper Teton River valley.

Table 13. FTR laboratory analyzed water quality parameters.

Analytical Parameter	Sample Size	Preservation	Holding Time	Method	Current Detection Limit
Nitrogen-nitrate/nitrite	50 mL	Cool 4 °C H_2SO_4 pH<2	28 days	EPA 300	0.05 mg/L
Ammonia	150 mL	Cool 4 °C H_2SO_4 pH<2	28 days	EPA 350.3	0.05 mg/L
Total phosphorus	100 mL	Cool 4 °C, H_2SO_4 pH<2	28 days	EPA 365.4	0.01 mg/L
Ortho phosphorus (as P)	100 mL	Filtered, Cool 4°C	24 hours	EPA 365.2	0.01 mg/L
E. coli	100 mL	Cool 4 °C	8 hours	EPA 1103.1	< 1 cfu/100 mL

4.2.6 DEQ Nutrient Monitoring Project

Nutrient Parameters

A nutrient study by DEQ was instituted in 2012 to respond to the concerns of nutrient enrichment posed by FTR. There were no identified impairments of the beneficial uses due to nutrients. However, it was determined that there were excessive sediment loads from streambank and hillslope erosion leading to width-depth concerns and potential excessive heating from solar radiation. The details of this study are contained in Appendix I. The primary finding was that sediment reductions should lead to nutrient reductions through limiting a significant nutrient source to the channel, and expected improvements will also decrease shallow ground water sources by establishing and improving woody-plant stands along the river corridor. An observed effect of the sediment was excessive growth of rooted macrophytes and short-term dissolved oxygen depletions in the early morning hours in the Teton River AU ID17040204SK028_03. Sediment TMDLs and associated allocations are developed in this document (see section 5.2). Detailed sediment methods and results are located in Appendix C. Macrophytes also serve as a food source for the abundant moose populations within the valley portion of the subbasin and provide cover and habitat for trout and other fishes (Figure 23).

Figure 23. Moose observed eating macrophytes (September 15, 2014).

Due to concerns with the continuous temperature monitoring associated with the nutrient study, it was determined that continuous monitoring throughout the salmonid spawning period was required to better examine the water quality and beneficial uses, as the nutrient study monitoring only captured a minimal portion of that spawning period. This determination was reinforced with the observation that the width-depth ratios in the upper Teton River were suggestive of many shallow, minimally shaded river stretches. Therefore, temperature data loggers were deployed in spring 2014. The results of these loggers are contained in Appendix E, and all 4 AUs had exceedances for temperature in the salmonid spawning period. Temperature TMDLs are included in section 5.1.

Associated with the nutrient monitoring program in 2012, data were collected and are summarized below that are directly relevant to the chemical sampling (Table 14; Appendix I). Details of the monitoring program, goals, results, and conclusions are located in Appendix I.

Table 14. Chemical monitoring descriptive statistics, 2012.

Variable	Unit	Location	N	Mean	Median	St Dev	Variance	Minimum	Maximum
Total Kjeldahl nitrogen	(mg/L)	TR1	20	0.34	0.34	0.11	0.01	0.17	0.71
		TR2	20	0.37	0.35	0.13	0.02	0.21	0.79
		TR3	20	0.43	0.40	0.14	0.02	0.23	0.80
		TR4	20	0.37	0.38	0.10	0.01	0.23	0.63
NO_2+NO_3:N	(mg/L)	TR1	20	1.05	1.10	0.32	0.10	0.01	1.30
		TR2	20	0.85	0.74	0.49	0.24	0.48	2.70
		TR3	20	0.90	0.94	0.14	0.02	0.54	1.00
		TR4	20	0.56	0.70	0.21	0.04	0.23	0.84
Total nitrogen	(mg/L)	TR1	20	1.39	1.46	0.27	0.07	0.66	1.66
		TR2	20	1.22	1.07	0.52	0.27	0.74	3.02
		TR3	20	1.33	1.36	0.11	0.01	0.97	1.48
		TR4	20	0.94	0.99	0.21	0.04	0.58	1.22
Total phosphorus	(mg/L)	TR1	20	0.027	0.018	0.022	0.000	0.013	0.100
		TR2	20	0.019	0.012	0.021	0.000	0.010	0.099
		TR3	20	0.031	0.024	0.022	0.001	0.016	0.095
		TR4	20	0.022	0.016	0.016	0.000	0.010	0.068
Chlorophyll *a*	(µg/L)	TR1	15	0.86	0.79	0.37	0.14	0.22	1.70
		TR2	14	0.93	0.85	0.52	0.27	0.22	2.30
		TR3	14	2.34	1.80	2.24	5.00	0.82	10.00
		TR4	15	1.56	1.60	0.52	0.27	0.55	2.30

Water Physical Parameters and Properties

Two Yellow Springs Instruments sondes (YSI 6920) were deployed in the upper and lower segments in the Teton River valley during the 2012 DEQ nutrient monitoring. These YSI sondes were deployed from July 16, 2012, until September 26, 2012, with regular quality assurance checks, cleaning, and calibrations. Data were collected on a 15-minute basis, which included pH, specific conductance, dissolved oxygen, and temperature. Temperature and turbidity data are not shown, as temperature data were collected in 2014 during the critical salmonid spawning period (Appendix E). Some gaps do appear in the data; these were removed as part of the quality control process and when removing data points collected during sonde maintenance.

pH Monitoring

The pH measurements were within the expected range for natural waters and meeting the criteria for aquatic uses (IDAPA 58.01.02.250), with pH measurements between 6.5 and 9.0. Diel (daily cycles) biologic activity is apparent in the pH variation in the upstream location (TR1) located downstream of the headwaters of the confluence of Warm and Drake Creeks when compared against the downstream location (TR4) at the Highway 33 Bridge (Figure 24).

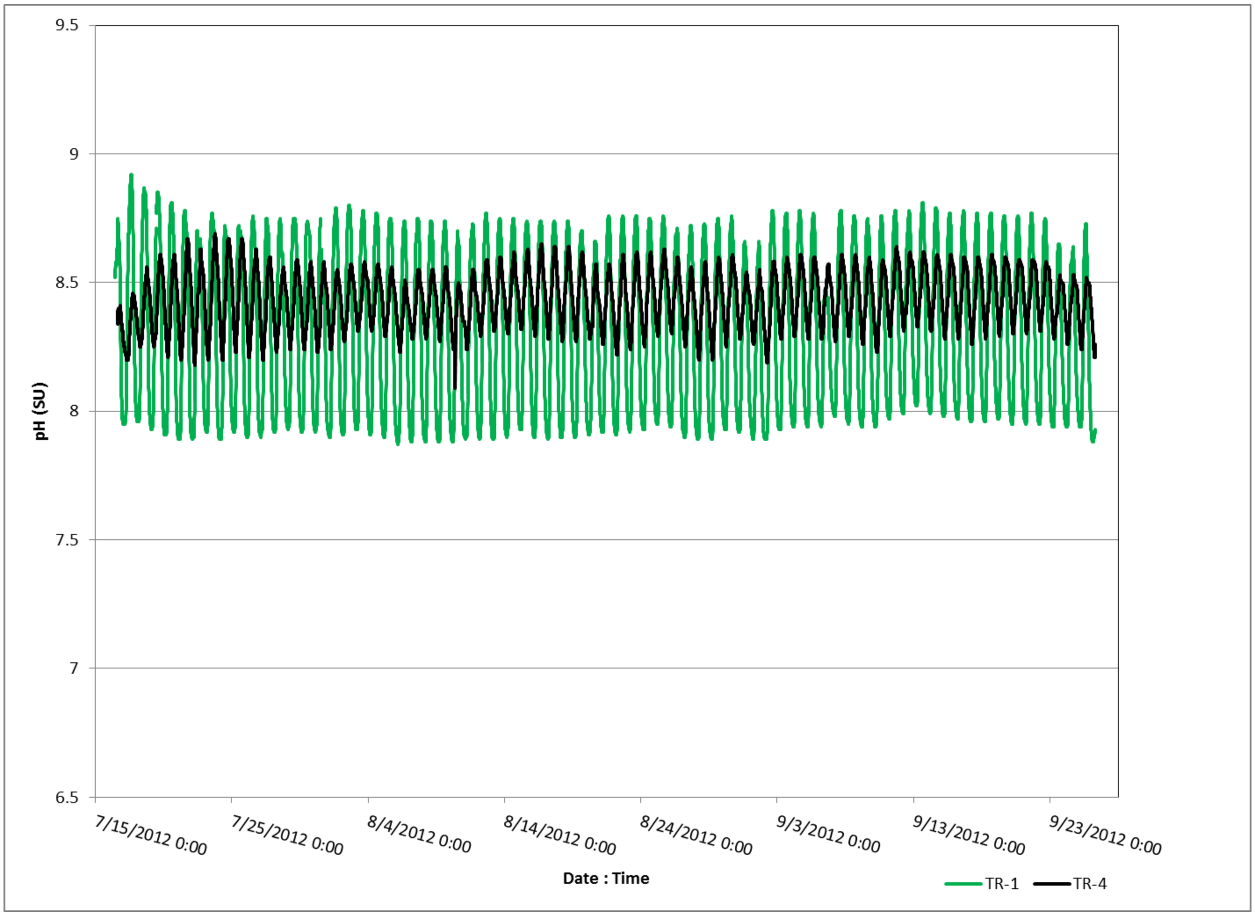

Figure 24. pH (standard units) measurements in the Teton River at Highway 33 (TR4) and below the headwaters confluence (TR1).

Specific Conductance Monitoring

The specific conductance was greater in the TR1 upstream location than in the downstream TR4 location (Figure 25). It is presumed that the ground water dominated upstream portion of the river contains more dissolved minerals and therefore has greater specific conductance. Observations of precipitates at the upstream reach on deployed equipment supports this interpretation and appeared to be calcium/magnesium–carbonate based precipitates.

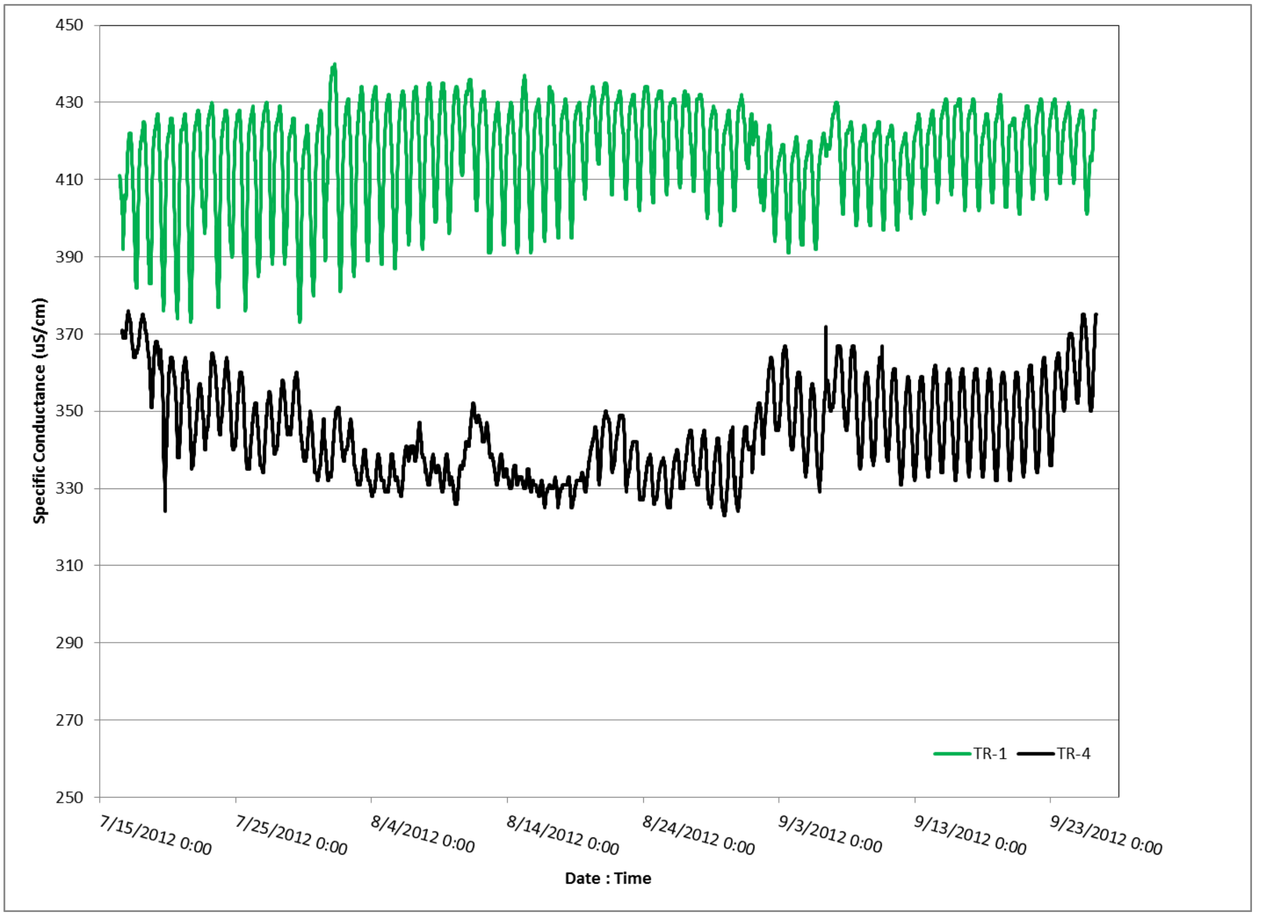

Figure 25. Specific conductance (µS/cm) measurements in the Teton River at Highway 33 (TR4) and below the headwaters confluence (TR-1).

Dissolved Oxygen Monitoring

The dissolved oxygen in the lower valley portion of the Teton River at Highway 33 (TR4) was typically within the expected range of dissolved oxygen and supportive of beneficial uses, specifically for cold water aquatic life. However, the upper section below the confluence of Warm and Drake Creeks (TR1) experienced nearly daily exceedances of the cold water aquatic life standard in July and August (Figure 26). This portion of the river has significant inputs of ground water and has a substrate composition dominated by fines and gravels and significant coverage by macrophytes. While these macrophytes do serve as habitat and cover for small fish and a food source for moose, the macrophytes photosynthesize during the day leading to high/saturated dissolved oxygen concentrations. At night they respire, causing significant fluctuations in the dissolved oxygen and nightly depletions below the 6 mg/L standard. These depletions are due to the macrophyte growth and is an observed effect of the fine sediment being highly supportive of that growth. The primary cause of the dissolved oxygen depletions was determined to be related to the sediment erosion and deposition within the channel providing both suitable conditions and nutrients; a sediment TMDL was developed (see section 5.2 for details).

Since the beneficial uses were found to be supported and the departures were brief, there is no impairment (IDAPA 58.01.02.054.03). Due to a calibration error, the TR1 location had a data correction factor applied for the July 14–31, 2012, dissolved oxygen data, but there is still a question on the overall applicability of the data for meeting quality assurance and Tier 1 requirements for assessment of impairments. However, upon re-calibration, the dissolved oxygen measurements at the TR1 location were all within acceptable variance.

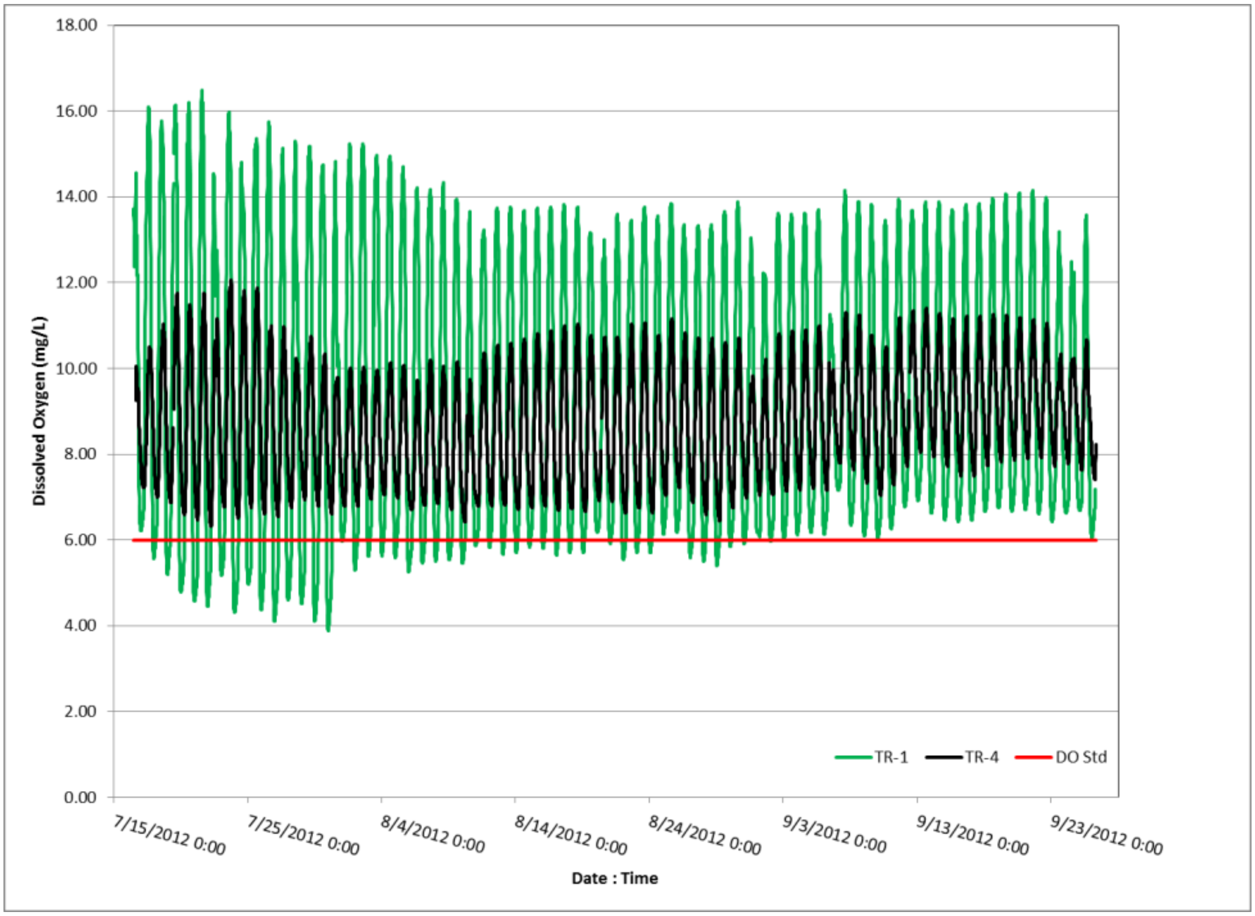

Figure 26. Dissolved oxygen (mg/L) measurements in the Teton River at Highway 33 (TR4) and below the headwaters confluence (TR1).

4.2.7 Beneficial Use Reconnaissance Monitoring

The database used by DEQ to manage assessments (ADB) contains a compilation of bioassessment data and determinations that have been collected statewide from 1994 through the most recent field season via the Beneficial Use Reconnaissance Program (BURP). Analyzing the habitat condition and populations of macroinvertebrates and fish is the most efficient and cost-effective means of determining long-term water quality in streams. Diversity of species, existence of species with a low tolerance to water quality impairments, and size of populations are just a few of the measures that demonstrate support status of beneficial uses. See Barbour et al. (1999) for more information about bioassessment protocols that identify water quality characteristics. The Teton River subbasin has been monitored for beneficial use support status through these bioassessment protocols (i.e., BURP monitoring). Pertinent BURP data are presented in Appendix H.

4.2.8 Idaho Department of Fish and Game

IDFG has monitored fish populations and their composition in the Teton River for nearly 20 years. Some of the collected data are presented below: from Nickerson monitoring reach (Figure 27), Buxton monitoring reach (Figure 28), and Breckenridge monitoring reach (Figure 29). The trout populations of specific interest to IDFG are Yellowstone Cutthroat Trout (YCT), Rainbow Trout (RBT), and Brook Trout (BKT). Fish numbers have increased since the late 1990s and early 2000s, with YCT numbers nearing their late 1980s levels. This increase is believed to be related to changes in management in and out of the stream channel and habitat and increased spawning access. (See section 4.1 for descriptions of water quality pollution improvement projects.)

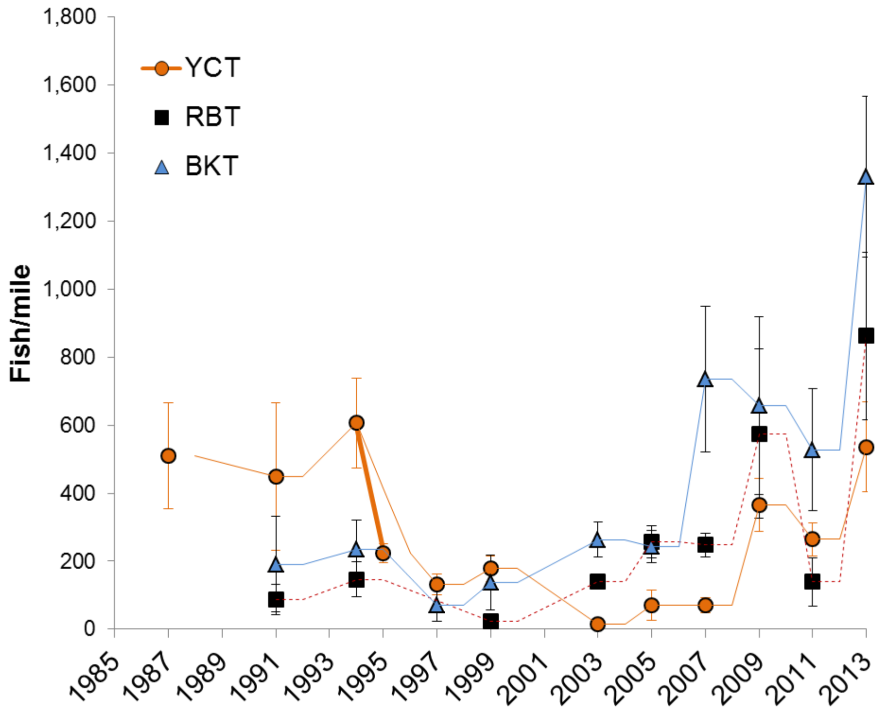

Figure 27. Fish per mile at the Nickerson monitoring reach on the Teton River. Data were collected using boat-mounted electrofishing gear and mark-recapture population estimate techniques. Additional information is available from IDFG.

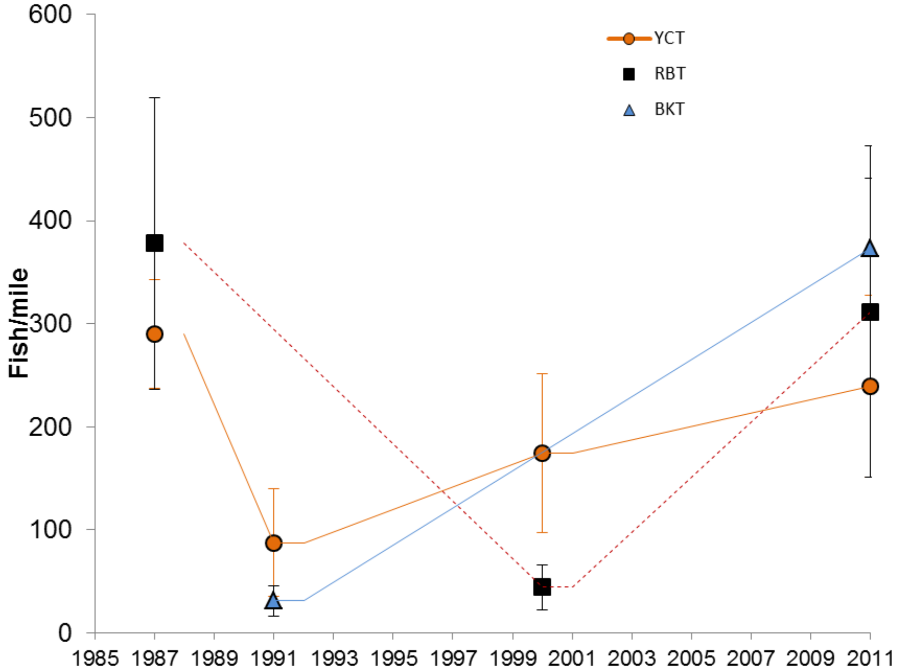

Figure 28. Fish per mile at the Buxton monitoring reach on the Teton River. Data were collected using boat-mounted electrofishing gear and mark-recapture population estimate techniques. Additional information is available from IDFG.

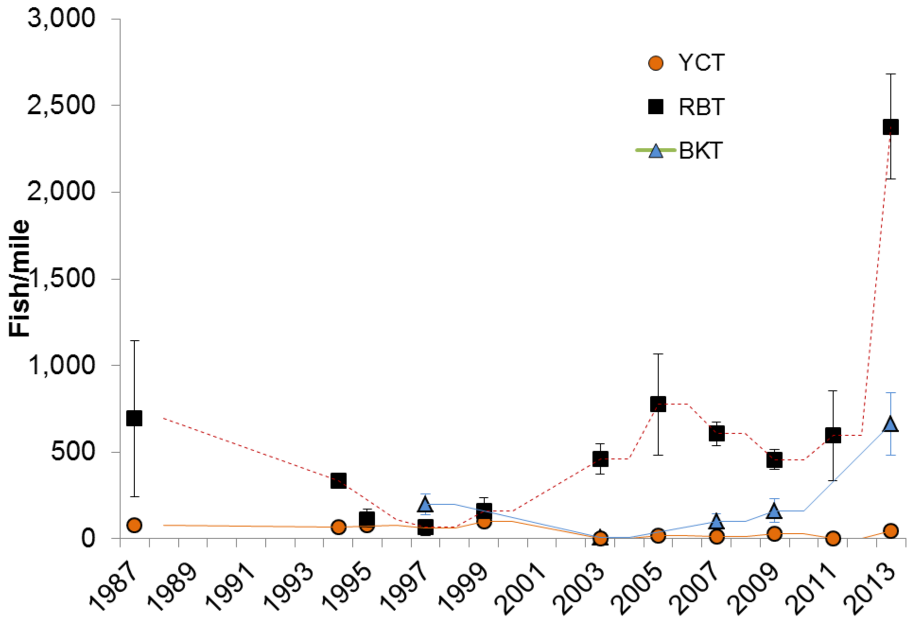

Figure 29. Fish per mile at the Breckenridge monitoring reach on the Teton River. Data were collected using boat-mounted electrofishing gear and mark-recapture population estimate techniques. Additional information is available from IDFG.

5 Total Maximum Daily Load(s)

A TMDL prescribes an upper limit (i.e., load capacity) on discharge of a pollutant from all sources to ensure water quality standards are met. It further allocates this load capacity among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation, and nonpoint sources, each of which receives a load allocation. Natural background contributions, when present, are considered part of the load allocation but are often treated separately because they represent a part of the load not subject to control. Because of uncertainties about quantifying loads and the relation of specific loads to attaining water quality standards, the rules regarding TMDLs (40 CFR Part 130) require a margin of safety be included in the TMDL. Practically, the margin of safety and natural background are both reductions in the load capacity available for allocation to pollutant sources.

Load capacity can be summarized by the following equation:

$$LC = MOS + NB + LA + WLA = TMDL$$

Where:

LC = load capacity
MOS = margin of safety
NB = natural background
LA = load allocation
WLA = wasteload allocation

The equation is written in this order because it represents the logical order in which a load analysis is conducted. First, the load capacity is determined. Then the load capacity is broken down into its components. After the necessary margin of safety and natural background, if relevant, are quantified, the remainder is allocated among pollutant sources (i.e., the load allocation and wasteload allocation). When the breakdown and allocation are complete, the result is a TMDL, which must equal the load capacity.

The load capacity must be based on critical conditions—the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determining critical conditions can be more complicated than it may initially appear.

Another step in a load analysis is quantifying current pollutant loads by source. This step allows for the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary for pollutant trading to occur. A load is fundamentally a quantity of pollutant discharged over some period of time and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary (40 CFR 130.2). These other measures must still be quantifiable and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 Temperature TMDL

5.1.1 Instream Water Quality Targets

For the 10 AUs addressed in these temperature TMDLs, we utilized a PNV approach. The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard, and for temperature TMDLS, the natural level of shade and channel width become the TMDL target. The instream temperature that results from attaining these conditions is consistent with the water quality standards, even if it exceeds numeric temperature criteria. See Appendix A for further discussion of water quality standards and natural background provisions.

The PNV approach is described briefly below. The procedures and methodologies to develop PNV target shade levels and to estimate existing shade levels are described in detail in *The Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual* (Shumar and De Varona 2009). The manual also provides a more complete discussion of shade and its effects on stream water temperature.

5.1.1.1 Factors Controlling Water Temperature in Streams

There are several important contributors of heat to a stream, including ground water temperature, air temperature, and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most controllable. The parameters that affect the amount of solar radiation hitting a stream throughout its length are shade and stream morphology. Shade is provided by the surrounding vegetation and other physical features such as hillsides, canyon walls, terraces, and high banks. Stream morphology (i.e., structure) affects riparian vegetation density and water storage in the alluvial aquifer. Riparian vegetation and channel morphology are the factors influencing shade that are most likely to have been influenced by anthropogenic activities and can be most readily corrected and addressed by a TMDL.

Riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. However, depending on how much vertical elevation surrounds the stream, vegetation further away from the riparian corridor can also provide shade. We can measure the amount of shade that a stream receives in a number of ways. Effective shade (i.e., that shade provided by all objects that intercept the sun as it makes its way across the sky) can be measured in a given location with a Solar Pathfinder or with other optical equipment similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and stream aspect.

In addition to shade, canopy cover is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream and can be measured using a densiometer or estimated visually either on-site or using aerial photography. All of these methods provide information about how much of the stream is covered and how much is exposed to direct solar radiation.

5.1.1.2 Potential Natural Vegetation for Temperature TMDLs

PNV along a stream is that riparian plant community that could grow to an overall mature state, although some level of natural disturbance is usually included in the development and use of shade targets. Vegetation can be removed by disturbance either naturally (e.g., wildfire, disease/old age, wind damage, wildlife grazing) or anthropogenically (e.g., domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade-producing vegetation. Vegetation levels less than PNV (with the exception of natural levels of disturbance and age distribution) result in the stream heating up from anthropogenically created additional solar inputs.

We can estimate PNV (and therefore target shade) from models of plant community structure (shade curves for specific riparian plant communities), and we can measure or estimate existing canopy cover or shade. Comparing the two (target and existing shade) tells us how much excess solar load the stream is receiving and what potential exists to decrease solar gain. Streams disturbed by wildfire, flood, or some other natural disturbance will be at less than PNV and require time to recover. Streams that have been disturbed by human activity may require additional restoration above and beyond natural recovery.

Existing and PNV shade was converted to solar loads from data collected on flat-plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather stations collecting these data. In this case, we used the station in Pocatello, Idaho. The difference between existing and target solar loads, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards (see Appendix A).

PNV shade and the associated solar loads are assumed to be the natural condition; thus, stream temperatures under PNV conditions are assumed to be natural (so long as no point sources or other anthropogenic sources of heat exist in the watershed) and are considered to be consistent with the Idaho water quality standards, even if they exceed numeric criteria by more than 0.3 °C.

Existing Shade Estimates

Existing shade was estimated for 9 AUs from visual interpretation of aerial photos. Estimates of existing shade based on plant type and density were marked out as stream segments on a 1:100,000 or 1:250,000 hydrography taking into account natural breaks in vegetation density. Stream segment length for each estimate of existing shade varies depending on the land use or landscape that has affected that shade level. Each segment was assigned a single value representing the bottom of a 10% shade class (adapted from the cumulative watershed effects process, IDL 2000). For example, if shade for a particular stream segment was estimated somewhere between 50% and 59%, we assigned a 50% shade class to that segment. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, and stream width. Streams where the banks and water are clearly visible are usually in low shade classes (10%, 20%, or 30%). Streams with dense forest or heavy brush where no portion of the stream is visible are usually in high shade classes (70%, 80%, or 90%). More open canopies where portions of the stream may be visible usually fall into moderate shade classes (40%, 50%, or 60%).

Visual estimates made from aerial photos are strongly influenced by canopy cover and do not always take into account topography or any shading that may occur from physical features other than vegetation. It is not always possible to visualize or anticipate shade characteristics resulting from topography and landform. However, research has shown that shade and canopy cover measurements are remarkably similar (OWEB 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade. The visual estimates of shade in this TMDL were partially field verified with a Solar Pathfinder, which measures effective shade and takes into consideration other physical features that block the sun from hitting the stream surface (e.g., hillsides, canyon walls, terraces, and man-made structures).

Solar Pathfinder Field Verification

The accuracy of the aerial photo interpretations was enhanced with a Solar Pathfinder at six sites. Unfortunately, data were not collected after aerial interpretations to field verify, but were used to produce the original aerial interpretation. The Solar Pathfinder is a device that allows one to trace the outline of shade-producing objects on monthly solar path charts. The percentage of the sun's path covered by these objects is the effective shade on the stream at the location where the tracing is made. To adequately characterize the effective shade on a stream segment, ten traces are taken at systematic or random intervals along the length of the stream in question.

At each sampling location, the Solar Pathfinder was placed in the middle of the stream at about the bankfull water level. Ten traces were taken following the manufacturer's instructions (i.e., orient to south and level). Systematic sampling was used because it is easiest to accomplish without biasing the sampling location. For each sampled segment, the sampler started at a unique location, such as 50 to 100 meters (m) from a bridge or fence line, and proceeded upstream or downstream taking additional traces at fixed intervals (e.g., every 50 m, 50 paces, etc.). Alternatively, one can randomly locate points of measurement by generating random numbers to be used as interval distances.

When possible, the sampler also measured bankfull widths, took notes, and photographed the landscape of the stream at several unique locations while taking traces. Special attention was given to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade-producing ones) were present. One can also take densiometer readings at the same location as Solar Pathfinder traces. These readings provide the potential to develop relationships between canopy cover and effective shade for a given stream.

Solar Pathfinder data were collected at three sites on Fox Creek, one wadeable site on the upper 3rd-order reach of Teton River, and on two river float trips where several hundred Solar Pathfinder measurements were taken along two major stretches of the river. These data were used to determine existing shade classes for these waters. They were also used in an effort to "calibrate our eyes" for aerial photo interpretation of existing shade on other waters within the analysis that did not have Solar Pathfinder data. Solar Pathfinder data on the Teton River and Fox Creek in any location rarely exceeded 10% shade.

Target Shade Determination

PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in Idaho (see Shumar and De Varona 2009). A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, shade decreases as vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community is able to provide at any given channel width.

Natural Bankfull Widths

Stream width must be known to calculate target shade since the width of a stream affects the amount of shade the stream receives. Bankfull width is used because it best approximates the width between the points on either side of the stream where riparian vegetation starts. Measures of current bankfull width may not reflect widths present under PNV (i.e., natural widths). As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase such that streams become wider and shallower. Shade produced by vegetation covers a lower percentage of the water surface in wider streams, and widened streams can also have less vegetative cover if shoreline vegetation has eroded away.

In the Teton Valley, streams and rivers are not confined to a single channel and in some cases can be highly anastomosed. Multiple channels make it difficult to accurately determine natural channel width based on drainage area relationships. Therefore, we used drainage area relationships to predict maximum likely channel widths, and so long as current channels were smaller than these predictions we used the existing channel widths as natural channel widths in our load analysis. We used regional curves for the major basins in Idaho—developed from data compiled by Diane Hopster of the Idaho Department of Lands—to estimate the likely limits of natural bankfull width (Figure 30).

For each stream evaluated in the load analysis, natural bankfull width was evaluated based on the drainage area of the Salmon Basin curve from Figure 30 (see Table 15). Although estimates from other curves were examined (i.e., Upper Snake, Payette/Weiser), the Salmon Basin curve was ultimately chosen because it tended to reflect the high snowmelt hydrology typically found within the Teton Valley. The Teton River drainage is within the Upper Snake Basin; however, that regional hydrologic curve tends to be dominated by drier conditions found throughout the Snake River plain. Existing width data was evaluated primarily from measurements on aerial photos and any available BURP sites.

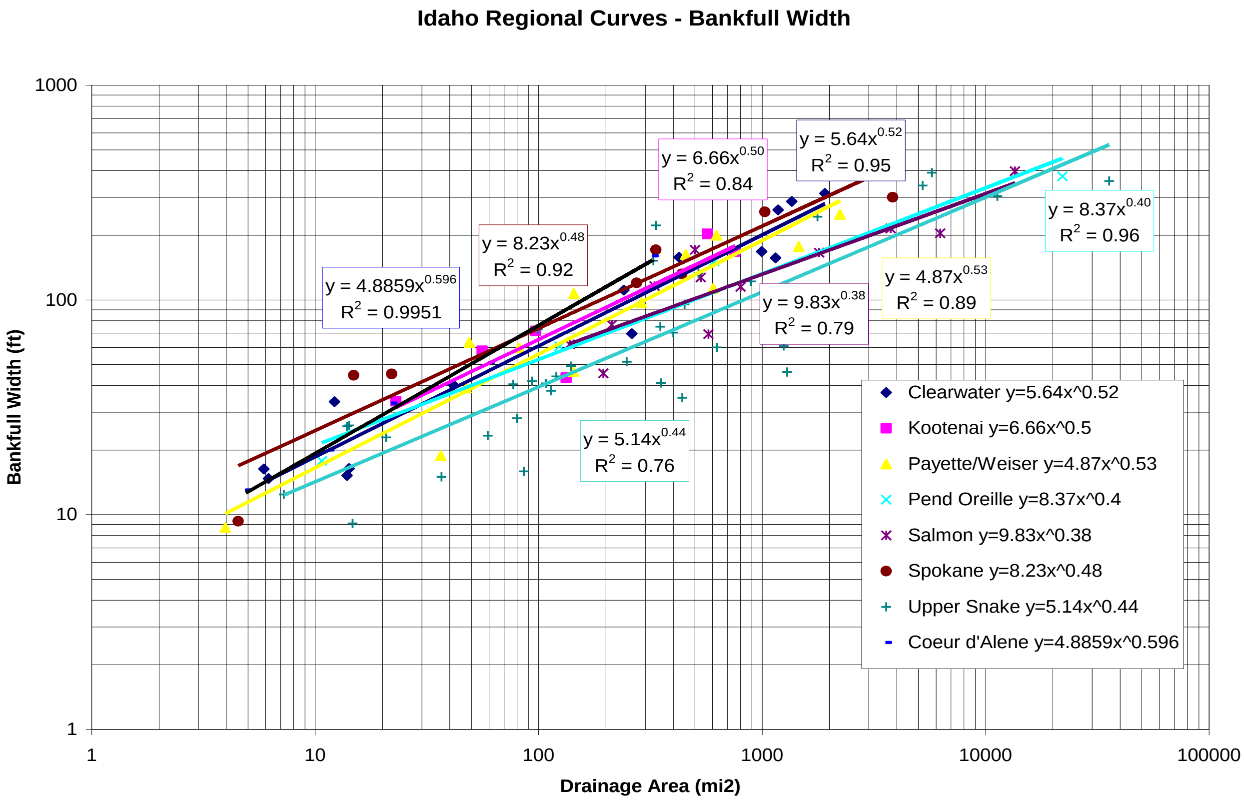

Figure 30. Bankfull width as a function of drainage area.

Table 15. Bankfull channel widths estimated by hydrologic rating curves.

Location	area (sq mi)	U Snake (m)	Salmon (m)	Payette/Weiser (m)
Teton River, end of AU #017_04	474.4	24	31	39
Teton River, start of AU #017_04	337	20	27	32
Teton River, start of AU #020_04	259.9	18	25	28
Teton River, end of AU #026_04	186.7	16	22	24
Teton River, start of AU #026_04	105.9	12	18	18
Teton River, end of AU #028_03	37.2	8	12	10
Teton River, start of AU #028_03	26.1	7	10	8
1st trib to Fox Creek	0.8	1	3	1
1st trib to Foster Slough	0.38	1	2	1
Elliott Creek @ mouth	4.05	3	5	3
Fish Creek @ mouth	4.88	3	5	3
Dry Fork @ Henderson Creek	1.54	2	4	2
Fox Creek @ mouth (Big Bend)	31.8	7	11	9
Fox Creek ab Foster Slough	27.6	7	11	9
Fox Creek @ Hwy 33	13.3	5	8	6
Fox Creek @ AU (041/042) boundary	12.2	5	8	6
Un-named below Fox Creek	1.4	2	3	2
Spring Creek ab N. Leigh Creek	14.26	5	8	6
Spring Creek bl Grouse Creek	12.68	5	8	6
Spring Creek @ mouth	39.1	8	12	10
Grouse Creek @ mouth	10.17	4	7	5
Grouse Creek ab Spring tributary	3.81	3	5	3
1st tributary to Spring Creek	6.26	4	6	4
2nd tributary to Spring Creek	1.23	2	3	2
3rd tributary to Spring Creek	1.66	2	4	2
4th tributary to Spring Creek	1.02	2	3	2
Tributary below badger Creek	1.15	2	3	2

In general, we found that existing channels were smaller than predicted by the Salmon Basin curve. However, there were locations where existing conditions greatly exceeded predicted widths, especially in the AU ID17040204SK026_04 region of the Teton River, where river widths may be three times wider than predicted values. Existing widths and natural widths are the same in load tables when no data support making them differ.

5.1.1.3 Design Conditions

The Teton River subbasin is found within the Dissected Plateaus and Teton Basin level 4 sub-ecoregion of the Snake River Plain ecoregion (McBride et al. 2001). The sub-ecoregion as a whole contains thick molisol soils from loess deposits that supported sagebrush steppe vegetation and is largely crop and pasture land today. Irrigated lands grow potatoes, alfalfa, and pasture, whereas nonirrigated lands support small grains. The Teton Basin portion of the sub-ecoregion is a relatively cold, poorly drained wet meadow complex. The current system potential for the Teton River and many of its tributaries includes willow complexes at lower elevations changing over to cottonwood and aspen stream corridors with increases in elevation. The headwater portions of some streams occur in coniferous forest.

5.1.1.4 Target Selection

To determine PNV shade targets for streams in the Teton Valley, effective shade curves from the Targhee National Forest and southern Idaho non-forest groups were examined (Table 16) (Shumar and De Varona 2009). These curves were produced using vegetation community modeling of Idaho plant communities. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. For the Teton Valley, curves for the most similar vegetation type were selected for shade target determinations. Although there are likely a variety of willow types along the Teton River and lower tributaries, we placed them within the Geyer willow/sedge vegetation type for target shade determinations. Tributary streams will change to aspen or cottonwood with increasing elevation. Coniferous headwaters include subalpine fir/Douglas-fir warm forests (ecological units 1224 and 1315) or spruce riparian (ecological unit 2609).

Table 16. Shade target vegetation types for the Teton Valley shade analysis.

Southern Idaho Non-forest Group	Targhee National Forest Ecological Units
Geyer willow/sedge	#1224 – subalpine fir/blue huckleberry
Aspen	#1315 – subalpine fir/sweetcicely/myrtle
Black cottonwood	#2609 – Engelmann’s spruce/ bedstraw/horsetail

5.1.2 Load Capacity

The load capacity for a stream under PNV is essentially the solar loading allowed under the shade targets specified for the segments within that stream. These loads are determined by multiplying the solar load measured by a flat-plate collector (under full sun) for a given period of time by the fraction of the solar radiation that is not blocked by shade (i.e., the percent open or 100% minus percent shade). In other words, if a shade target is 60% (or 0.6), the solar load hitting the stream under that target is 40% of the load hitting the flat-plate collector under full sun.

We obtained solar load data from flat-plate collectors at the NREL weather station in Pocatello, Idaho. The solar load data used in this TMDL analysis are spring/summer averages (i.e., an average load for the 6-month period from April through September). As such, load capacity calculations are also based on this 6-month period, which coincides with the time of year when stream temperatures are increasing, deciduous vegetation is in leaf, and fall spawning is occurring. During this period, temperatures may affect beneficial uses such as spring and fall salmonid spawning, and cold water aquatic life criteria may be exceeded during summer months. Late July and early August typically represent the period of highest stream temperatures. However, solar gains can begin early in the spring and affect not only the highest temperatures reached later in the summer but also salmonid spawning temperatures in spring and fall.

Tables 17–26 and Figure 31 show the PNV shade targets. The tables also show corresponding target summer loads (in kilowatt-hours per square meter per day [kWh/m^2/day] and kWh/day) that serve as the load capacities for the streams. Existing and target loads in kWh/day can be summed for the entire stream or portion of stream examined in a single load analysis table. These total loads are shown at the bottom of their respective columns in each table. Because load calculations involve stream segment area calculations, the segment's channel width, which typically only has one or two significant figures, dictates the level of significance of the corresponding loads. One significant figure in the resulting load can create rounding errors when existing and target loads are subtracted. The totals row of each load table represents total loads with two significant figures in an attempt to reduce apparent rounding errors.

The AU with the largest target load (i.e., load capacity) was Teton River (AU ID17040204SK020_04) with 2.7 million kWh/day (Table 18). The smallest target load was in the Fox Creek AU (ID17040204SK042_02) with 31,000 kWh/day (Table 23).

5.1.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR §130.2(I)). An estimate must be made for each point source. Nonpoint sources are typically estimated based on the type of sources (land use) and area (such as a subwatershed) but may be aggregated by type of source or area. To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads.

Existing loads in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. There are currently no permitted point sources in the affected AUs. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat-plate collector at the NREL weather station. Existing shade data are presented in Tables 17–26 and Figure 32. Like load capacities (target loads), existing loads in Tables 17–26 are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day). Existing loads in kWh/day are also summed for the entire stream or portion of stream examined in a single load analysis table. The difference between target and existing load is also summed for the entire table. Should existing load exceed target load, this difference becomes the excess load (i.e., shade deficit) to be discussed next in the load allocation section and as depicted in the shade deficit figures (Figure 33).

The AU with the largest existing load was Teton River (AU ID17040204SK020_04) with 3.7 million kWh/day (Table 18). The smallest existing load was in the Fox Creek AU (ID17040204SK042_02) with 23,000 kWh/day (Table 23).

Table 17. Existing and target solar loads for the Teton River (ID17040204SK017_04).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
017_04	Teton River	1	2200	Geyer willow	10%	5.54	28	62,000	340,000	0%	6.15	28	62,000	380,000	40,000	-10%
017_04	Teton River	2	650	Geyer willow	17%	5.10	16	10,000	51,000	0%	6.15	16	10,000	62,000	11,000	-17%
017_04	Teton River	3	240	Geyer willow	31%	4.24	8	2,000	8,000	10%	5.54	8	2,000	10,000	2,000	-21%
017_04	Teton River	4	170	Geyer willow	40%	3.69	6	1,000	4,000	0%	6.15	6	1,000	6,000	2,000	-40%
017_04	Teton River	5	690	Geyer willow	40%	3.69	6	4,000	10,000	20%	4.92	6	4,000	20,000	10,000	-20%
017_04	Teton River	6	1200	Geyer willow	14%	5.29	20	24,000	130,000	0%	6.15	20	24,000	150,000	20,000	-14%
017_04	Teton River	7	290	Geyer willow	26%	4.55	10	2,900	13,000	10%	5.54	10	2,900	16,000	3,000	-16%
017_04	Teton River	8	77	Geyer willow	26%	4.55	10	770	3,500	0%	6.15	10	770	4,700	1,200	-26%
017_04	Teton River	9	300	Geyer willow	9%	5.60	30	9,000	50,000	0%	6.15	30	9,000	55,000	5,000	-9%
017_04	Teton River	10	1100	Geyer willow	17%	5.10	16	18,000	92,000	0%	6.15	16	18,000	110,000	18,000	-17%
017_04	Teton River	11	770	Geyer willow	11%	5.47	25	19,000	100,000	0%	6.15	25	19,000	120,000	20,000	-11%
017_04	Teton River	12	540	Geyer willow	45%	3.38	5	3,000	10,000	70%	1.85	5	3,000	6,000	(4,000)	0%
017_04	Teton River	13	68	Geyer willow	14%	5.29	20	1,400	7,400	0%	6.15	20	1,400	8,600	1,200	-14%
017_04	Teton River	14	260	Geyer willow	35%	4.00	7	2,000	8,000	20%	4.92	7	2,000	10,000	2,000	-15%
017_04	Teton River	15	860	Geyer willow	14%	5.29	20	17,000	90,000	0%	6.15	20	17,000	100,000	10,000	-14%
017_04	Teton River	16	310	Geyer willow	11%	5.47	25	7,800	43,000	0%	6.15	25	7,800	48,000	5,000	-11%
017_04	Teton River	17	340	Geyer willow	9%	5.60	30	10,000	56,000	0%	6.15	30	10,000	62,000	6,000	-9%
017_04	Teton River	18	420	Geyer willow	64%	2.21	3	1,000	2,000	40%	3.69	3	1,000	4,000	2,000	-24%
017_04	Teton River	19	2430	Geyer willow	11%	5.47	25	61,000	330,000	0%	6.15	25	61,000	380,000	50,000	-11%
017_04	Teton River	20	230	Geyer willow	35%	4.00	7	2,000	8,000	0%	6.15	7	2,000	10,000	2,000	-35%
017_04	Teton River	21	560	Geyer willow	53%	2.89	4	2,000	6,000	20%	4.92	4	2,000	10,000	4,000	-33%
017_04	Teton River	22	220	Geyer willow	35%	4.00	7	2,000	8,000	0%	6.15	7	2,000	10,000	2,000	-35%
017_04	Teton River	23	280	Geyer willow	11%	5.47	25	7,000	38,000	0%	6.15	25	7,000	43,000	5,000	-11%
017_04	Teton River	24	190	Geyer willow	53%	2.89	4	800	2,000	40%	3.69	4	800	3,000	1,000	-13%
017_04	Teton River	25	82	Geyer willow	31%	4.24	8	700	3,000	0%	6.15	8	700	4,000	1,000	-31%
017_04	Teton River	26	360	Geyer willow	11%	5.47	25	9,000	49,000	0%	6.15	25	9,000	55,000	6,000	-11%
017_04	Teton River	27	590	Geyer willow	31%	4.24	8	5,000	20,000	0%	6.15	8	5,000	30,000	10,000	-31%
017_04	Teton River	28	940	Geyer willow	35%	4.00	7	7,000	30,000	0%	6.15	7	7,000	40,000	10,000	-35%
017_04	Teton River	29	1800	Geyer willow	11%	5.47	25	45,000	250,000	0%	6.15	25	45,000	280,000	30,000	-11%
017_04	Teton River	30	1400	Geyer willow	53%	2.89	4	6,000	20,000	0%	6.15	4	6,000	40,000	20,000	-53%
017_04	Teton River	31	260	Geyer willow	22%	4.80	12	3,100	15,000	0%	6.15	12	3,100	19,000	4,000	-22%
017_04	Teton River	32	130	Geyer willow	26%	4.55	10	1,300	5,900	0%	6.15	10	1,300	8,000	2,100	-26%
017_04	Teton River	33	150	Geyer willow	45%	3.38	5	800	3,000	10%	5.54	5	800	4,000	1,000	-35%
017_04	Teton River	34	280	Geyer willow	45%	3.38	5	1,000	3,000	40%	3.69	5	1,000	4,000	1,000	-5%
017_04	Teton River	35	1600	Geyer willow	9%	5.60	30	48,000	270,000	0%	6.15	30	48,000	300,000	30,000	-9%
017_04	Teton River	36	290	Geyer willow	9%	5.60	32	9,300	52,000	0%	6.15	32	9,300	57,000	5,000	-9%
							Totals		2,100,000					2,500,000	340,000	

Note: All assessment unit (AU) numbers start with ID17040204SK in all load tables (Tables 17–26). Significant figures are controlled by the lowest level in the calculation, typically that of the channel width. Some rounding errors may result.

Table 18. Existing and target solar loads for the Teton River (ID17040204SK020_04).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
020_04	Teton River	1	1400	Geyer willow	11%	5.47	25	35,000	190,000	0%	6.15	40	56,000	340,000	150,000	-11%
020_04	Teton River	2	110	Geyer willow	11%	5.47	25	2,800	15,000	0%	6.15	33	3,600	22,000	7,000	-11%
020_04	Teton River	3	1400	Geyer willow	11%	5.47	25	35,000	190,000	0%	6.15	40	56,000	340,000	150,000	-11%
020_04	Teton River	4	490	Geyer willow	16%	5.17	17	8,300	43,000	0%	6.15	17	8,300	51,000	8,000	-16%
020_04	Teton River	5	370	Geyer willow	14%	5.29	20	7,400	39,000	0%	6.15	20	7,400	46,000	7,000	-14%
020_04	Teton River	6	430	Geyer willow	11%	5.47	25	11,000	60,000	0%	6.15	42	18,000	110,000	50,000	-11%
020_04	Teton River	7	1600	Geyer willow	11%	5.47	25	40,000	220,000	0%	6.15	40	64,000	390,000	170,000	-11%
020_04	Teton River	8	470	Geyer willow	11%	5.47	25	12,000	66,000	0%	6.15	37	17,000	100,000	34,000	-11%
020_04	Teton River	9	840	Geyer willow	12%	5.41	23	19,000	100,000	0%	6.15	23	19,000	120,000	20,000	-12%
020_04	Teton River	10	1000	Geyer willow	11%	5.47	26	26,000	140,000	0%	6.15	30	30,000	180,000	40,000	-11%
020_04	Teton River	11	1100	Geyer willow	15%	5.23	18	20,000	100,000	0%	6.15	18	20,000	120,000	20,000	-15%
020_04	Teton River	12	120	Geyer willow	18%	5.04	15	1,800	9,100	0%	6.15	15	1,800	11,000	1,900	-18%
020_04	Teton River	13	1600	Geyer willow	14%	5.29	20	32,000	170,000	0%	6.15	20	32,000	200,000	30,000	-14%
020_04	Teton River	14	110	Geyer willow	11%	5.47	26	2,900	16,000	0%	6.15	35	3,900	24,000	8,000	-11%
020_04	Teton River	15	380	Geyer willow	22%	4.80	12	4,600	22,000	0%	6.15	12	4,600	28,000	6,000	-22%
020_04	Teton River	16	280	Geyer willow	12%	5.41	23	6,400	35,000	0%	6.15	23	6,400	39,000	4,000	-12%
020_04	Teton River	17	280	Geyer willow	19%	4.98	14	3,900	19,000	0%	6.15	14	3,900	24,000	5,000	-19%
020_04	Teton River	18	180	Geyer willow	22%	4.80	12	2,200	11,000	10%	5.54	12	2,200	12,000	1,000	-12%
020_04	Teton River	19	200	Geyer willow	22%	4.80	12	2,400	12,000	0%	6.15	12	2,400	15,000	3,000	-22%
020_04	Teton River	20	330	Geyer willow	13%	5.35	22	7,300	39,000	0%	6.15	22	7,300	45,000	6,000	-13%
020_04	Teton River	21	250	Geyer willow	12%	5.41	23	5,800	31,000	0%	6.15	23	5,800	36,000	5,000	-12%
020_04	Teton River	22	1100	Geyer willow	11%	5.47	26	29,000	160,000	0%	6.15	30	33,000	200,000	40,000	-11%
020_04	Teton River	23	670	Geyer willow	11%	5.47	26	17,000	93,000	0%	6.15	32	21,000	130,000	37,000	-11%
020_04	Teton River	24	430	Geyer willow	10%	5.54	27	12,000	66,000	0%	6.15	33	14,000	86,000	20,000	-10%
020_04	Teton River	25	2000	Geyer willow	10%	5.54	27	54,000	300,000	0%	6.15	30	60,000	370,000	70,000	-10%
020_04	Teton River	26	1100	Geyer willow	11%	5.47	26	29,000	160,000	0%	6.15	26	29,000	180,000	20,000	-11%
020_04	Teton River	27	680	Geyer willow	21%	4.86	13	8,800	43,000	0%	6.15	13	8,800	54,000	11,000	-21%
020_04	Teton River	28	1300	Geyer willow	10%	5.54	27	35,000	190,000	0%	6.15	30	39,000	240,000	50,000	-10%
020_04	Teton River	29	650	Geyer willow	14%	5.29	20	13,000	69,000	0%	6.15	20	13,000	80,000	11,000	-14%
020_04	Teton River	30	970	Geyer willow	19%	4.98	14	14,000	70,000	0%	6.15	14	14,000	86,000	16,000	-19%
							Totals		2,700,000					3,700,000	1,000,000	

Table 19. Existing and target solar loads for Teton River tributaries (ID17040204SK026_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
026_02	1st Trib to Fox Cr	1	250	Geyer willow	64%	2.21	3	800	2,000	20%	4.92	3	800	4,000	2,000	-44%
026_02	1st Trib to Fox Cr	2	80	Geyer willow	64%	2.21	3	200	400	0%	6.15	2	200	1,000	600	-64%
026_02	1st Trib to Fox Cr	3	300	Geyer willow	53%	2.89	4	1,000	3,000	20%	4.92	2	600	3,000	0	-33%
026_02	1st Trib to Fox Cr	4	420	Geyer willow	45%	3.38	5	2,000	7,000	40%	3.69	3	1,000	4,000	(3,000)	-5%
026_02	1st Trib to Fox Cr	5	54	Geyer willow	40%	3.69	6	300	1,000	0%	6.15	7	400	2,000	1,000	-40%
026_02	1st Trib to Fox Cr	6	55	Geyer willow	40%	3.69	6	300	1,000	60%	2.46	5	300	700	(300)	0%
026_02	1st Trib to Fox Cr	7	150	Geyer willow	40%	3.69	6	900	3,000	0%	6.15	8	1,000	6,000	3,000	-40%
026_02	1st Trib to Fox Cr	8	140	Geyer willow	40%	3.69	6	800	3,000	10%	5.54	5	700	4,000	1,000	-30%
026_02	1st Trib to Fox Cr	9	210	Geyer willow	35%	4.00	7	1,000	4,000	0%	6.15	6	1,000	6,000	2,000	-35%
026_02	1st Trib to Fox Cr	10	90	Geyer willow	35%	4.00	7	600	2,000	10%	5.54	6	500	3,000	1,000	-25%
026_02	1st Trib to Fox Cr	11	280	Geyer willow	35%	4.00	7	2,000	8,000	30%	4.31	6	2,000	9,000	1,000	-5%
026_02	1st Trib to Fox Cr	12	740	Geyer willow	31%	4.24	8	6,000	30,000	20%	4.92	6	4,000	20,000	(10,000)	-11%
026_02	1st Trib to Fox Cr	13	320	Geyer willow	29%	4.37	9	3,000	10,000	0%	6.15	9	3,000	20,000	10,000	-29%
026_02	2nd trib to Fox Cr	1	360	Geyer willow	40%	3.69	6	2,000	7,000	10%	5.54	6	2,000	10,000	3,000	-30%
026_02	2nd trib to Fox Cr	2	610	Geyer willow	26%	4.55	10	6,100	28,000	0%	6.15	10	6,100	38,000	10,000	-26%
026_02	3rd trib to Fox Cr	1	410	Geyer willow	82%	1.11	2	800	900	20%	4.92	2	800	4,000	3,000	-62%
026_02	3rd trib to Fox Cr	2	180	spring	0%	6.15	11	2,000	12,000	0%	6.15	11	2,000	12,000	0	0%
026_02	3rd trib to Fox Cr	3	930	Geyer willow	64%	2.21	3	3,000	7,000	10%	5.54	3	3,000	20,000	10,000	-54%
026_02	3rd trib to Fox Cr	4	1300	Geyer willow	35%	4.00	7	9,000	40,000	0%	6.15	7	9,000	60,000	20,000	-35%
026_02	Foster Slough	1	1400	Geyer willow	18%	5.04	15	21,000	110,000	10%	5.54	15	21,000	120,000	10,000	-8%
026_02	Foster Slough	2	1000	Geyer willow	35%	4.00	7	7,000	30,000	10%	5.54	7	7,000	40,000	10,000	-25%
026_02	Foster Slough	3	1100	Geyer willow	18%	5.04	15	17,000	86,000	10%	5.54	15	17,000	94,000	8,000	-8%
026_02	Foster Slough	4	110	Geyer willow	12%	5.41	23	2,500	14,000	0%	6.15	23	2,500	15,000	1,000	-12%
026_02	Foster Slough	5	140	Geyer willow	16%	5.17	17	2,400	12,000	0%	6.15	17	2,400	15,000	3,000	-16%
026_02	Foster Slough	6	65	Geyer willow	14%	5.29	20	1,300	6,900	0%	6.15	20	1,300	8,000	1,100	-14%
026_02	Foster Slough	7	320	Geyer willow	64%	2.21	3	1,000	2,000	10%	5.54	3	1,000	6,000	4,000	-54%
026_02	Foster Slough	8	580	Geyer willow	35%	4.00	7	4,000	20,000	0%	6.15	7	4,000	20,000	0	-35%
026_02	Foster Slough	9	620	Geyer willow	15%	5.23	18	11,000	58,000	0%	6.15	18	11,000	68,000	10,000	-15%
026_02	Foster Slough	10	160	Geyer willow	7%	5.72	40	6,400	37,000	0%	6.15	40	6,400	39,000	2,000	-7%
026_02	1st trib to Foster	1	900	Geyer willow	93%	0.43	1	900	400	40%	3.69	1	900	3,000	3,000	-53%
026_02	1st trib to Foster	2	150	Geyer willow	93%	0.43	1	200	90	60%	2.46	3	500	1,000	900	-33%
026_02	1st trib to Foster	3	270	pond	0%	6.15	60	16,000	98,000	0%	6.15	60	16,000	98,000	0	0%
026_02	1st trib to Foster	4	1300	Geyer willow	82%	1.11	2	3,000	3,000	20%	4.92	2	3,000	10,000	7,000	-62%
026_02	1st trib to Foster	5	460	Geyer willow	82%	1.11	2	900	1,000	0%	6.15	5	2,000	10,000	9,000	-82%

Table 19 (cont.). Existing and target solar loads for Teton River tributaries (ID17040204SK026_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
026_02	Elliott Creek	1	670	Geyer willow	93%	0.43	1	700	300	10%	5.54	2	1,000	6,000	6,000	-83%
026_02	Elliott Creek	2	220	Geyer willow	93%	0.43	1	200	90	20%	4.92	2	400	2,000	2,000	-73%
026_02	Elliott Creek	3	240	Geyer willow	82%	1.11	2	500	600	0%	6.15	3	700	4,000	3,000	-82%
026_02	Elliott Creek	4	870	Geyer willow	82%	1.11	2	2,000	2,000	40%	3.69	3	3,000	10,000	8,000	-42%
026_02	Elliott Creek	5	320	Geyer willow	64%	2.21	3	1,000	2,000	80%	1.23	3	1,000	1,000	(1,000)	0%
026_02	Elliott Creek	6	320	Geyer willow	64%	2.21	3	1,000	2,000	30%	4.31	4	1,000	4,000	2,000	-34%
026_02	Elliott Creek	7	92	Geyer willow	53%	2.89	4	400	1,000	0%	6.15	4	400	2,000	1,000	-53%
026_02	Elliott Creek	8	140	Geyer willow	53%	2.89	4	600	2,000	60%	2.46	4	600	1,000	(1,000)	0%
026_02	Elliott Creek	9	120	Geyer willow	53%	2.89	4	500	1,000	0%	6.15	5	600	4,000	3,000	-53%
026_02	Elliott Creek	10	260	Geyer willow	53%	2.89	4	1,000	3,000	30%	4.31	5	1,000	4,000	1,000	-23%
026_02	Elliott Creek	11	76	Geyer willow	53%	2.89	4	300	900	60%	2.46	5	400	1,000	100	0%
026_02	Elliott Creek	12	110	Geyer willow	53%	2.89	4	400	1,000	30%	4.31	5	600	3,000	2,000	-23%
026_02	Elliott Creek	13	760	Geyer willow	45%	3.38	5	4,000	10,000	0%	6.15	6	5,000	30,000	20,000	-45%
026_02	Fish Creek	1	59	Geyer willow	93%	0.43	1	60	30	20%	4.92	3	200	1,000	1,000	-73%
026_02	Fish Creek	2	95	Geyer willow	93%	0.43	1	100	40	60%	2.46	3	300	700	700	-33%
026_02	Fish Creek	3	150	Geyer willow	93%	0.43	1	200	90	40%	3.69	3	500	2,000	2,000	-53%
026_02	Fish Creek	4	210	Geyer willow	93%	0.43	1	200	90	80%	1.23	3	600	700	600	-13%
026_02	Fish Creek	5	100	Geyer willow	93%	0.43	1	100	40	50%	3.08	3	300	900	900	-43%
026_02	Fish Creek	6	140	Geyer willow	82%	1.11	2	300	300	40%	3.69	3	400	1,000	700	-42%
026_02	Fish Creek	7	170	Geyer willow	82%	1.11	2	300	300	20%	4.92	3	500	2,000	2,000	-62%
026_02	Fish Creek	8	260	Geyer willow	82%	1.11	2	500	600	0%	6.15	3	800	5,000	4,000	-82%
026_02	Fish Creek	9	210	Geyer willow	64%	2.21	3	600	1,000	30%	4.31	3	600	3,000	2,000	-34%
026_02	Fish Creek	10	180	Geyer willow	64%	2.21	3	500	1,000	0%	6.15	3	500	3,000	2,000	-64%
026_02	Fish Creek	11	130	Geyer willow	64%	2.21	3	400	900	20%	4.92	3	400	2,000	1,000	-44%
026_02	Fish Creek	12	1400	Geyer willow	45%	3.38	5	7,000	20,000	0%	6.15	4	6,000	40,000	20,000	-45%
026_02	Dry Fork	1	2200	EU# 1315	78%	1.35	2	4,000	5,000	90%	0.62	2	4,000	2,000	(3,000)	0%
026_02	Dry Fork	2	730	EU# 1315	67%	2.03	3	2,000	4,000	90%	0.62	3	2,000	1,000	(3,000)	0%
026_02	Dry Fork	3	410	Geyer willow	53%	2.89	4	2,000	6,000	60%	2.46	4	2,000	5,000	(1,000)	0%
026_02	Dry Fork	4	130	Geyer willow	53%	2.89	4	500	1,000	90%	0.62	4	500	300	(700)	0%
026_02	Dry Fork	5	61	pond	0%	6.15	20	1,200	7,400	0%	6.15	20	1,200	7,400	0	0%
026_02	Paradise Spring	1	330	pond	0%	6.15	20	6,600	41,000	0%	6.15	20	6,600	41,000	0	0%
026_02	Paradise Creek	2	560	Geyer willow	53%	2.89	4	2,000	6,000	50%	3.08	4	2,000	6,000	0	-3%
026_02	Paradise Creek	3	1600	Geyer willow	45%	3.38	5	8,000	30,000	0%	6.15	5	8,000	50,000	20,000	-45%
026_02	Miller Slough	1	360	Geyer willow	22%	4.80	12	4,300	21,000	0%	6.15	12	4,300	26,000	5,000	-22%
							Totals		820,000					1,000,000	220,000	

Table 20. Existing and target solar loads for the Teton River (ID17040204SK026_04).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
026_04	Teton River	1	2300	Geyer willow	15%	5.23	18	41,000	210,000	0%	6.15	20	46,000	280,000	70,000	-15%
026_04	Teton River	2	280	Geyer willow	14%	5.29	19	5,300	28,000	0%	6.15	22	6,200	38,000	10,000	-14%
026_04	Teton River	3	130	Geyer willow	31%	4.24	8	1,000	4,000	0%	6.15	8	1,000	6,000	2,000	-31%
026_04	Teton River	4	54	Geyer willow	14%	5.29	19	1,000	5,300	0%	6.15	22	1,200	7,400	2,100	-14%
026_04	Teton River	5	62	Geyer willow	14%	5.29	19	1,200	6,300	0%	6.15	20	1,200	7,400	1,100	-14%
026_04	Teton River	6	210	Geyer willow	14%	5.29	20	4,200	22,000	0%	6.15	32	6,700	41,000	19,000	-14%
026_04	Teton River	7	770	Geyer willow	14%	5.29	20	15,000	79,000	0%	6.15	54	42,000	260,000	180,000	-14%
026_04	Teton River	8	240	Geyer willow	14%	5.29	20	4,800	25,000	0%	6.15	63	15,000	92,000	67,000	-14%
026_04	Teton River	9	250	Geyer willow	14%	5.29	20	5,000	26,000	0%	6.15	62	16,000	98,000	72,000	-14%
026_04	Teton River	10	1800	Geyer willow	13%	5.35	21	38,000	200,000	0%	6.15	63	110,000	680,000	480,000	-13%
026_04	Teton River	11	440	Geyer willow	13%	5.35	21	9,200	49,000	0%	6.15	50	22,000	140,000	91,000	-13%
026_04	Teton River	12	1200	Geyer willow	13%	5.35	22	26,000	140,000	0%	6.15	63	76,000	470,000	330,000	-13%
026_04	Teton River	13	630	Geyer willow	13%	5.35	22	14,000	75,000	0%	6.15	50	32,000	200,000	130,000	-13%
								Totals	870,000					2,300,000	1,500,000	

Table 21. Existing and target solar loads for the Teton River (ID17040204SK028_03).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
028_03	Teton River	1	230	Geyer willow	26%	4.55	10	2,300	10,000	10%	5.54	7	1,600	8,900	(1,100)	-16%
028_03	Teton River	2	850	Geyer willow	26%	4.55	10	8,500	39,000	0%	6.15	13	11,000	68,000	29,000	-26%
028_03	Teton River	3	680	Geyer willow	24%	4.67	11	7,500	35,000	0%	6.15	13	8,800	54,000	19,000	-24%
028_03	Teton River	4	800	Geyer willow	24%	4.67	11	8,800	41,000	0%	6.15	12	9,600	59,000	18,000	-24%
028_03	Teton River	5	130	Geyer willow	24%	4.67	11	1,400	6,500	10%	5.54	12	1,600	8,900	2,400	-14%
028_03	Teton River	6	550	Geyer willow	22%	4.80	12	6,600	32,000	0%	6.15	12	6,600	41,000	9,000	-22%
028_03	Teton River	7	180	Geyer willow	22%	4.80	12	2,200	11,000	10%	5.54	10	1,800	10,000	(1,000)	-12%
028_03	Teton River	8	240	Geyer willow	22%	4.80	12	2,900	14,000	0%	6.15	11	2,600	16,000	2,000	-22%
028_03	Teton River	9	49	Geyer willow	22%	4.80	12	590	2,800	10%	5.54	10	490	2,700	(100)	-12%
028_03	Teton River	10	110	Geyer willow	22%	4.80	12	1,300	6,200	0%	6.15	12	1,300	8,000	1,800	-22%
028_03	Teton River	11	360	Geyer willow	22%	4.80	12	4,300	21,000	0%	6.15	14	5,000	31,000	10,000	-22%
							Totals		220,000					310,000	89,000	

Table 22. Existing and target solar loads for Fox Creek (ID17040204SK041_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
041_02	Fox Creek	1	130	EU# 2609	84%	0.98	8	1,000	1,000	60%	2.46	8	1,000	2,000	1,000	-24%
041_02	Fox Creek	2	1100	EU# 2609	84%	0.98	8	9,000	9,000	80%	1.23	8	9,000	10,000	1,000	-4%
041_02	Fox Creek	3	1200	cottonwood	86%	0.86	8	10,000	9,000	70%	1.85	8	10,000	20,000	10,000	-16%
041_02	Fox Creek	4	580	cottonwood	86%	0.86	8	5,000	4,000	80%	1.23	8	5,000	6,000	2,000	-6%
041_02	Fox Creek	5	1470	cottonwood	86%	0.86	8	10,000	9,000	70%	1.85	8	10,000	20,000	10,000	-16%
041_02	Fox Creek	6	470	cottonwood	86%	0.86	8	4,000	3,000	80%	1.23	8	4,000	5,000	2,000	-6%
041_02	Fox Creek	7	30	cottonwood	86%	0.86	8	200	200	0%	6.15	8	200	1,000	800	-86%
041_02	Fox Creek	8	400	cottonwood	86%	0.86	8	3,000	3,000	80%	1.23	8	3,000	4,000	1,000	-6%
041_02	Fox Creek	9	69	cottonwood	86%	0.86	8	600	500	0%	6.15	8	600	4,000	4,000	-86%
041_02	Fox Creek	10	1300	cottonwood	86%	0.86	8	10,000	9,000	80%	1.23	8	10,000	10,000	1,000	-6%
041_02	Fox Creek	11	160	Geyer willow	45%	3.38	8	1,000	3,000	60%	2.46	8	1,000	2,000	(1,000)	0%
041_02	Fox Creek	12	85	Geyer willow	45%	3.38	8	700	2,000	30%	4.31	8	700	3,000	1,000	-15%
041_02	Fox Creek	13	83	Geyer willow	45%	3.38	8	700	2,000	0%	6.15	8	700	4,000	2,000	-45%
041_02	Fox Creek	14	110	Geyer willow	45%	3.38	8	900	3,000	50%	3.08	8	900	3,000	0	0%
041_02	Fox Creek	15	170	Geyer willow	45%	3.38	8	1,000	3,000	10%	5.54	8	1,000	6,000	3,000	-35%
041_02	Fox Creek	16	170	Geyer willow	45%	3.38	8	1,000	3,000	0%	6.15	8	1,000	6,000	3,000	-45%
041_02	Fox Creek	17	3800	Geyer willow	26%	4.55	10	38,000	170,000	0%	6.15	10	38,000	230,000	60,000	-26%
041_02	Fox Creek	18	78	Geyer willow	24%	4.67	11	860	4,000	0%	6.15	17	1,300	8,000	4,000	-24%
041_02	Fox Creek	19	330	Geyer willow	24%	4.67	11	3,600	17,000	0%	6.15	15	5,000	31,000	14,000	-24%
041_02	Fox Creek	20	490	Geyer willow	24%	4.67	11	5,400	25,000	0%	6.15	20	9,800	60,000	35,000	-24%
041_02	Fox Creek	21	280	Geyer willow	24%	4.67	11	3,100	14,000	0%	6.15	15	4,200	26,000	12,000	-24%
041_02	Fox Creek (rt fork)	1	510	Geyer willow	64%	2.21	3	2,000	4,000	70%	1.85	3	2,000	4,000	0	0%
041_02	Fox Creek	2	310	Geyer willow	64%	2.21	3	900	2,000	60%	2.46	3	900	2,000	0	-4%
041_02	Fox Creek	3	230	Geyer willow	64%	2.21	3	700	2,000	70%	1.85	3	700	1,000	(1,000)	0%
041_02	Fox Creek	4	590	Geyer willow	64%	2.21	3	2,000	4,000	40%	3.69	3	2,000	7,000	3,000	-24%
041_02	Fox Creek	5	350	Geyer willow	64%	2.21	3	1,000	2,000	60%	2.46	3	1,000	2,000	0	-4%
041_02	Fox Creek	6	280	Geyer willow	64%	2.21	3	800	2,000	40%	3.69	3	800	3,000	1,000	-24%
041_02	Fox Creek (lt fork)	1	2200	Geyer willow	64%	2.21	3	7,000	20,000	60%	2.46	3	7,000	20,000	0	-4%
041_02	un-named bl Fox	1	710	EU# 1315	80%	1.23	1	700	900	90%	0.62	1	700	400	(500)	0%
041_02	un-named bl Fox	2	440	EU# 1315	78%	1.35	2	900	1,000	80%	1.23	2	900	1,000	0	0%
041_02	un-named bl Fox	3	440	Geyer willow	82%	1.11	2	900	1,000	30%	4.31	3	1,000	4,000	3,000	-52%
041_02	un-named bl Fox	4	180	Geyer willow	64%	2.21	3	500	1,000	60%	2.46	3	500	1,000	0	-4%
041_02	un-named bl Fox	5	110	Geyer willow	64%	2.21	3	300	700	10%	5.54	3	300	2,000	1,000	-54%
041_02	un-named bl Fox	6	290	Geyer willow	64%	2.21	3	900	2,000	50%	3.08	3	900	3,000	1,000	-14%
041_02	un-named bl Fox	7	45	Geyer willow	64%	2.21	3	100	200	0%	6.15	3	100	600	400	-64%
041_02	un-named bl Fox	8	190	Geyer willow	64%	2.21	3	600	1,000	30%	4.31	3	600	3,000	2,000	-34%
041_02	un-named bl Fox	9	35	Geyer willow	64%	2.21	3	100	200	0%	6.15	3	100	600	400	-64%
							Totals		340,000					520,000	180,000	

Table 23. Existing and target solar loads for Fox Creek (ID17040204SK042_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
042_02	Fox Creek	1	820	EU# 2609	64%	2.21	8	7,000	20,000	70%	1.85	8	7,000	10,000	(10,000)	0%
042_02	Fox Creek	2	280	EU# 2609	64%	2.21	8	2,000	4,000	50%	3.08	8	2,000	6,000	2,000	-14%
042_02	Fox Creek	3	370	EU# 2609	64%	2.21	8	3,000	7,000	60%	2.46	8	3,000	7,000	0	-4%
							Totals		31,000					23,000	-8,000	

Table 24. Existing and target solar loads for Spring Creek (ID17040204SK054_03).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
054_03	Spring Creek	1	89	Geyer willow	31%	4.24	8	700	3,000	50%	3.08	8	700	2,000	(1,000)	0%
054_03	Spring Creek	2	270	Geyer willow	31%	4.24	8	2,000	8,000	10%	5.54	8	2,000	10,000	2,000	-21%
054_03	Spring Creek	3	640	Geyer willow	31%	4.24	8	5,000	20,000	30%	4.31	8	5,000	20,000	0	-1%
054_03	Spring Creek	4	140	Geyer willow	31%	4.24	8	1,000	4,000	20%	4.92	8	1,000	5,000	1,000	-11%
054_03	Spring Creek	5	150	Geyer willow	31%	4.24	8	1,000	4,000	30%	4.31	8	1,000	4,000	0	-1%
054_03	Spring Creek	6	130	Geyer willow	22%	4.80	12	1,600	7,700	20%	4.92	12	1,600	7,900	200	-2%
054_03	Spring Creek	7	90	Geyer willow	22%	4.80	12	1,100	5,300	0%	6.15	12	1,100	6,800	1,500	-22%
054_03	Spring Creek	8	130	Geyer willow	26%	4.55	10	1,300	5,900	30%	4.31	10	1,300	5,600	(300)	0%
054_03	Spring Creek	9	150	Geyer willow	26%	4.55	10	1,500	6,800	20%	4.92	10	1,500	7,400	600	-6%
054_03	Spring Creek	10	200	Geyer willow	26%	4.55	10	2,000	9,100	30%	4.31	10	2,000	8,600	(500)	0%
054_03	Spring Creek	11	140	Geyer willow	26%	4.55	10	1,400	6,400	10%	5.54	10	1,400	7,700	1,300	-16%
054_03	Spring Creek	12	150	Geyer willow	26%	4.55	10	1,500	6,800	40%	3.69	10	1,500	5,500	(1,300)	0%
054_03	Spring Creek	13	500	Geyer willow	22%	4.80	12	6,000	29,000	20%	4.92	12	6,000	30,000	1,000	-2%
054_03	Spring Creek	14	580	Geyer willow	26%	4.55	10	5,800	26,000	40%	3.69	10	5,800	21,000	(5,000)	0%
054_03	Spring Creek	15	340	Geyer willow	40%	3.69	6	2,000	7,000	50%	3.08	6	2,000	6,000	(1,000)	0%
054_03	Spring Creek	16	420	Geyer willow	40%	3.69	6	3,000	10,000	40%	3.69	6	3,000	10,000	0	0%
054_03	Spring Creek	17	81	Geyer willow	35%	4.00	7	600	2,000	0%	6.15	7	600	4,000	2,000	-35%
054_03	Spring Creek	18	300	Geyer willow	35%	4.00	7	2,000	8,000	10%	5.54	7	2,000	10,000	2,000	-25%
054_03	Spring Creek	19	290	Geyer willow	45%	3.38	5	1,000	3,000	10%	5.54	5	1,000	6,000	3,000	-35%
054_03	Spring Creek	20	270	Geyer willow	53%	2.89	4	1,000	3,000	0%	6.15	4	1,000	6,000	3,000	-53%
054_03	Spring Creek	21	200	Geyer willow	40%	3.69	6	1,000	4,000	0%	6.15	6	1,000	6,000	2,000	-40%
054_03	Spring Creek	22	140	Geyer willow	40%	3.69	6	800	3,000	70%	1.85	6	800	1,000	(2,000)	0%
054_03	Spring Creek	23	870	Geyer willow	40%	3.69	6	5,000	20,000	0%	6.15	6	5,000	30,000	10,000	-40%
054_03	Spring Creek	24	150	Geyer willow	40%	3.69	6	900	3,000	20%	4.92	6	900	4,000	1,000	-20%
054_03	Spring Creek	25	89	Geyer willow	40%	3.69	6	500	2,000	0%	6.15	6	500	3,000	1,000	-40%
054_03	Spring Creek	26	200	Geyer willow	40%	3.69	6	1,000	4,000	10%	5.54	6	1,000	6,000	2,000	-30%
054_03	Spring Creek	27	830	Geyer willow	45%	3.38	5	4,000	10,000	30%	4.31	5	4,000	20,000	10,000	-15%

Table 24 (cont.). Existing and target solar loads for Spring Creek (ID17040204SK054_03).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
054_03	Spring Creek	28	440	Geyer willow	45%	3.38	5	2,000	7,000	20%	4.92	5	2,000	10,000	3,000	-25%
054_03	Spring Creek	29	1100	Geyer willow	45%	3.38	5	6,000	20,000	40%	3.69	5	6,000	20,000	0	-5%
054_03	Spring Creek	30	310	Geyer willow	40%	3.69	6	2,000	7,000	20%	4.92	6	2,000	10,000	3,000	-20%
054_03	Spring Creek	31	310	Geyer willow	53%	2.89	4	1,000	3,000	30%	4.31	4	1,000	4,000	1,000	-23%
054_03	Spring Creek	32	330	Geyer willow	53%	2.89	4	1,000	3,000	10%	5.54	4	1,000	6,000	3,000	-43%
054_03	Spring Creek	33	420	Geyer willow	31%	4.24	8	3,000	10,000	50%	3.08	8	3,000	9,000	(1,000)	0%
054_03	Spring Creek	34	300	Geyer willow	26%	4.55	10	3,000	14,000	30%	4.31	10	3,000	13,000	(1,000)	0%
054_03	Spring Creek	35	440	Geyer willow	26%	4.55	10	4,400	20,000	60%	2.46	10	4,400	11,000	(9,000)	0%
054_03	Spring Creek	36	150	Geyer willow	26%	4.55	10	1,500	6,800	40%	3.69	10	1,500	5,500	(1,300)	0%
054_03	Spring Creek	37	220	Geyer willow	26%	4.55	10	2,200	10,000	10%	5.54	10	2,200	12,000	2,000	-16%
054_03	Spring Creek	38	200	Geyer willow	26%	4.55	10	2,000	9,100	30%	4.31	10	2,000	8,600	(500)	0%
054_03	Spring Creek	39	980	Geyer willow	31%	4.24	8	8,000	30,000	60%	2.46	8	8,000	20,000	(10,000)	0%
054_03	Spring Creek	40	280	Geyer willow	31%	4.24	8	2,000	8,000	0%	6.15	8	2,000	10,000	2,000	-31%
054_03	Spring Creek	41	390	Geyer willow	53%	2.89	4	2,000	6,000	10%	5.54	4	2,000	10,000	4,000	-43%
054_03	Spring Creek	42	510	Geyer willow	64%	2.21	3	2,000	4,000	30%	4.31	3	2,000	9,000	5,000	-34%
054_03	Spring Creek	43	950	Geyer willow	82%	1.11	2	2,000	2,000	20%	4.92	2	2,000	10,000	8,000	-62%
054_03	Spring Creek	44	910	Geyer willow	53%	2.89	4	4,000	10,000	0%	6.15	4	4,000	20,000	10,000	-53%
054_03	Spring Creek	45	420	Geyer willow	53%	2.89	4	2,000	6,000	20%	4.92	4	2,000	10,000	4,000	-33%
054_03	Spring Creek	46	250	Geyer willow	53%	2.89	4	1,000	3,000	50%	3.08	4	1,000	3,000	0	-3%
054_03	Spring Creek	47	690	Geyer willow	53%	2.89	4	3,000	9,000	20%	4.92	4	3,000	10,000	1,000	-33%
054_03	Spring Creek	48	610	Geyer willow	64%	2.21	3	2,000	4,000	0%	6.15	3	2,000	10,000	6,000	-64%
054_03	Spring Creek	49	1000	Geyer willow	64%	2.21	3	3,000	7,000	20%	4.92	3	3,000	10,000	3,000	-44%
054_03	Spring Creek	50	360	Geyer willow	53%	2.89	4	1,000	3,000	20%	4.92	4	1,000	5,000	2,000	-33%
054_03	Spring Creek	51	470	Geyer willow	29%	4.37	9	4,000	20,000	40%	3.69	9	4,000	10,000	(10,000)	0%
054_03	Spring Creek	52	810	Geyer willow	45%	3.38	5	4,000	10,000	70%	1.85	5	4,000	7,000	(3,000)	0%
054_03	Spring Creek	53	570	Geyer willow	45%	3.38	5	3,000	10,000	50%	3.08	5	3,000	9,000	(1,000)	0%
054_03	Spring Creek	54	130	Geyer willow	53%	2.89	4	500	1,000	40%	3.69	4	500	2,000	1,000	-13%
054_03	Spring Creek	55	190	Geyer willow	53%	2.89	4	800	2,000	0%	6.15	4	800	5,000	3,000	-53%
							Totals		470,000					520,000	57,000	

Table 25. Existing and target solar loads for Spring Creek (ID17040204SK056_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
056_02	Spring Creek	1	840	Geyer willow	18%	5.04	15	13,000	66,000	0%	6.15	15	13,000	80,000	14,000	-18%
056_02	Spring Creek	2	770	Geyer willow	16%	5.17	17	13,000	67,000	0%	6.15	17	13,000	80,000	13,000	-16%
056_02	Grouse Creek	1	1700	EU #1224	73%	1.66	1	2,000	3,000	90%	0.62	1	2,000	1,000	(2,000)	0%
056_02	Grouse Creek	2	230	EU #1224	73%	1.66	1	200	300	70%	1.85	1	200	400	100	-3%
056_02	Grouse Creek	3	180	aspen	100%	0.00	1	200	0	90%	0.62	1	200	100	100	-10%
056_02	Grouse Creek	4	27	aspen	100%	0.00	1	30	0	0%	6.15	1	30	200	200	-100%
056_02	Grouse Creek	5	100	aspen	100%	0.00	1	100	0	90%	0.62	1	100	60	60	-10%
056_02	Grouse Creek	6	90	aspen	100%	0.00	1	90	0	70%	1.85	1	90	200	200	-30%
056_02	Grouse Creek	7	660	aspen	99%	0.06	2	1,000	60	90%	0.62	2	1,000	600	500	-9%
056_02	Grouse Creek	8	350	cottonwood	97%	0.18	2	700	100	30%	4.31	2	700	3,000	3,000	-67%
056_02	Grouse Creek	9	930	cottonwood	97%	0.18	2	2,000	400	80%	1.23	2	2,000	2,000	2,000	-17%
056_02	Grouse Creek	10	390	cottonwood	97%	0.18	2	800	100	70%	1.85	2	800	1,000	900	-27%
056_02	Grouse Creek	11	510	cottonwood	96%	0.25	3	2,000	500	80%	1.23	3	2,000	2,000	2,000	-16%
056_02	Grouse Creek	12	150	cottonwood	96%	0.25	3	500	100	40%	3.69	3	500	2,000	2,000	-56%
056_02	Grouse Creek	13	560	cottonwood	96%	0.25	3	2,000	500	80%	1.23	3	2,000	2,000	2,000	-16%
056_02	Grouse Creek	14	120	Geyer willow	64%	2.21	3	400	900	30%	4.31	3	400	2,000	1,000	-34%
056_02	Grouse Creek	15	430	Geyer willow	64%	2.21	3	1,000	2,000	0%	6.15	3	1,000	6,000	4,000	-64%
056_02	Grouse Creek	16	560	Geyer willow	64%	2.21	3	2,000	4,000	20%	4.92	3	2,000	10,000	6,000	-44%
056_02	Grouse Creek	17	150	Geyer willow	64%	2.21	3	500	1,000	0%	6.15	3	500	3,000	2,000	-64%
056_02	Grouse Creek	18	56	Geyer willow	64%	2.21	3	200	400	10%	5.54	3	200	1,000	600	-54%
056_02	Grouse Creek	19	110	Geyer willow	64%	2.21	3	300	700	0%	6.15	3	300	2,000	1,000	-64%
056_02	Grouse Creek	20	66	Geyer willow	64%	2.21	3	200	400	20%	4.92	3	200	1,000	600	-44%
056_02	trib to Grouse	1	640	cottonwood	96%	0.25	3	2,000	500	90%	0.62	3	2,000	1,000	500	-6%
056_02	trib to Grouse	2	1400	cottonwood	96%	0.25	3	4,000	1,000	80%	1.23	3	4,000	5,000	4,000	-16%
056_02	1st trib to Spring	1	2800	EU #1224	73%	1.66	1	3,000	5,000	90%	0.62	1	3,000	2,000	(3,000)	0%
056_02	1st trib to Spring	2	990	aspen	99%	0.06	2	2,000	100	80%	1.23	2	2,000	2,000	2,000	-19%
056_02	1st trib to Spring	3	920	aspen	99%	0.06	3	3,000	200	90%	0.62	3	3,000	2,000	2,000	-9%
056_02	1st trib to Spring	4	630	Geyer willow	64%	2.21	3	2,000	4,000	70%	1.85	3	2,000	4,000	0	0%
056_02	1st trib to Spring	5	750	Geyer willow	64%	2.21	3	2,000	4,000	60%	2.46	3	2,000	5,000	1,000	-4%
056_02	1st trib to Spring	6	150	Geyer willow	53%	2.89	4	600	2,000	50%	3.08	4	600	2,000	0	-3%
056_02	1st trib to Spring	7	450	Geyer willow	53%	2.89	4	2,000	6,000	40%	3.69	4	2,000	7,000	1,000	-13%
056_02	1st trib to Spring	8	110	Geyer willow	53%	2.89	4	400	1,000	30%	4.31	4	400	2,000	1,000	-23%
056_02	1st trib to Spring	9	450	Geyer willow	53%	2.89	4	2,000	6,000	40%	3.69	4	2,000	7,000	1,000	-13%
056_02	1st trib to Spring	10	460	Geyer willow	53%	2.89	4	2,000	6,000	0%	6.15	4	2,000	10,000	4,000	-53%
056_02	1st trib to Spring	11	110	Geyer willow	53%	2.89	4	400	1,000	30%	4.31	4	400	2,000	1,000	-23%

Table 25 (cont.). Existing and target solar loads for Spring Creek (ID17040204SK056_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
056_02	2nd trib to Spring	1	760	aspen	100%	0.00	1	800	0	60%	2.46	1	800	2,000	2,000	-40%
056_02	2nd trib to Spring	2	86	aspen	100%	0.00	1	90	0	90%	0.62	1	90	60	60	-10%
056_02	2nd trib to Spring	3	180	aspen	100%	0.00	1	200	0	60%	2.46	1	200	500	500	-40%
056_02	2nd trib to Spring	4	170	aspen	100%	0.00	1	200	0	90%	0.62	1	200	100	100	-10%
056_02	2nd trib to Spring	5	320	aspen	99%	0.06	2	600	40	70%	1.85	2	600	1,000	1,000	-29%
056_02	2nd trib to Spring	6	140	aspen	99%	0.06	2	300	20	50%	3.08	2	300	900	900	-49%
056_02	2nd trib to Spring	7	390	aspen	99%	0.06	2	800	50	80%	1.23	2	800	1,000	1,000	-19%
056_02	2nd trib to Spring	8	88	aspen	99%	0.06	2	200	10	50%	3.08	2	200	600	600	-49%
056_02	2nd trib to Spring	9	700	aspen	99%	0.06	2	1,000	60	80%	1.23	2	1,000	1,000	900	-19%
056_02	2nd trib to Spring	10	140	aspen	99%	0.06	3	400	20	0%	6.15	3	400	2,000	2,000	-99%
056_02	2nd trib to Spring	11	320	aspen	99%	0.06	3	1,000	60	80%	1.23	3	1,000	1,000	900	-19%
056_02	2nd trib to Spring	12	160	Geyer willow	64%	2.21	3	500	1,000	70%	1.85	3	500	900	(100)	0%
056_02	2nd trib to Spring	13	78	Geyer willow	64%	2.21	3	200	400	0%	6.15	3	200	1,000	600	-64%
056_02	2nd trib to Spring	14	69	Geyer willow	64%	2.21	3	200	400	70%	1.85	3	200	400	0	0%
056_02	3rd trib to Spring	1	81	EU #1224	73%	1.66	1	80	100	0%	6.15	1	80	500	400	-73%
056_02	3rd trib to Spring	2	2000	EU #1224	73%	1.66	1	2,000	3,000	80%	1.23	1	2,000	2,000	(1,000)	0%
056_02	3rd trib to Spring	3	87	aspen	99%	0.06	2	200	10	60%	2.46	2	200	500	500	-39%
056_02	3rd trib to Spring	4	350	aspen	99%	0.06	2	700	40	80%	1.23	2	700	900	900	-19%
056_02	3rd trib to Spring	5	590	aspen	99%	0.06	2	1,000	60	70%	1.85	2	1,000	2,000	2,000	-29%
056_02	3rd trib to Spring	6	280	aspen	99%	0.06	3	800	50	50%	3.08	3	800	2,000	2,000	-49%
056_02	3rd trib to Spring	7	270	aspen	99%	0.06	3	800	50	80%	1.23	3	800	1,000	1,000	-19%
056_02	3rd trib to Spring	8	530	aspen	99%	0.06	3	2,000	100	50%	3.08	3	2,000	6,000	6,000	-49%
056_02	3rd trib to Spring	9	350	aspen	99%	0.06	3	1,000	60	90%	0.62	3	1,000	600	500	-9%
056_02	3rd trib to Spring	10	200	Geyer willow	53%	2.89	4	800	2,000	50%	3.08	4	800	2,000	0	-3%
056_02	3rd trib to Spring	11	180	Geyer willow	53%	2.89	4	700	2,000	80%	1.23	4	700	900	(1,000)	0%
056_02	3rd trib to Spring	12	810	Geyer willow	53%	2.89	4	3,000	9,000	40%	3.69	4	3,000	10,000	1,000	-13%
056_02	3rd trib to Spring	13	220	Geyer willow	53%	2.89	4	900	3,000	70%	1.85	4	900	2,000	(1,000)	0%
056_02	4th trib to Spring	1	2000	Geyer willow	64%	2.21	3	6,000	10,000	60%	2.46	4	8,000	20,000	10,000	-4%
056_02	4th trib to Spring	2	290	Geyer willow	64%	2.21	3	900	2,000	20%	4.92	28	8,000	40,000	40,000	-44%
056_02	Trib bl Badger Creek	1	840	Geyer willow	64%	2.21	3	3,000	7,000	40%	3.69	3	3,000	10,000	3,000	-24%
056_02	Trib bl Badger Creek	2	450	Geyer willow	64%	2.21	3	1,000	2,000	60%	2.46	3	1,000	2,000	0	-4%
056_02	Trib bl Badger Creek	3	210	Geyer willow	64%	2.21	3	600	1,000	20%	4.92	3	600	3,000	2,000	-44%
056_02	Trib bl Badger Creek	4	210	Geyer willow	64%	2.21	3	600	1,000	60%	2.46	3	600	1,000	0	-4%
056_02	Trib bl Badger Creek	5	230	Geyer willow	64%	2.21	3	700	2,000	40%	3.69	4	900	3,000	1,000	-24%
056_02	Trib bl Badger Creek	6	330	Geyer willow	64%	2.21	3	1,000	2,000	60%	2.46	3	1,000	2,000	0	-4%
056_02	Trib bl Badger Creek	7	730	Geyer willow	64%	2.21	3	2,000	4,000	30%	4.31	3	2,000	9,000	5,000	-34%
056_02	Trib bl Badger Creek	8	1100	Geyer willow	64%	2.21	3	3,000	7,000	40%	3.69	6	7,000	30,000	20,000	-24%
056_02	Trib bl Badger Creek	9	76	Geyer willow	64%	2.21	3	200	400	0%	6.15	30	2,000	10,000	10,000	-64%
							Totals		240,000					420,000	180,000	

Table 26. Existing and target solar loads for Spring Creek (ID17040204SK056_03).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
056_03	Spring Creek	1	290	Geyer willow	40%	3.69	6	2,000	7,000	60%	2.46	6	2,000	5,000	(2,000)	0%
056_03	Spring Creek	2	250	Geyer willow	40%	3.69	6	2,000	7,000	30%	4.31	6	2,000	9,000	2,000	-10%
056_03	Spring Creek	3	400	Geyer willow	40%	3.69	6	2,000	7,000	0%	6.15	6	2,000	10,000	3,000	-40%
056_03	Spring Creek	4	130	Geyer willow	40%	3.69	6	800	3,000	20%	4.92	6	800	4,000	1,000	-20%
056_03	Spring Creek	5	32	Geyer willow	40%	3.69	6	200	700	0%	6.15	6	200	1,000	300	-40%
056_03	Spring Creek	6	130	Geyer willow	40%	3.69	6	800	3,000	10%	5.54	6	800	4,000	1,000	-30%
056_03	Spring Creek	7	85	Geyer willow	40%	3.69	6	500	2,000	0%	6.15	6	500	3,000	1,000	-40%
056_03	Spring Creek	8	71	Geyer willow	40%	3.69	6	400	1,000	10%	5.54	6	400	2,000	1,000	-30%
056_03	Spring Creek	9	160	Geyer willow	35%	4.00	7	1,000	4,000	0%	6.15	7	1,000	6,000	2,000	-35%
056_03	Spring Creek	10	46	Geyer willow	35%	4.00	7	300	1,000	10%	5.54	7	300	2,000	1,000	-25%
056_03	Spring Creek	11	55	Geyer willow	35%	4.00	7	400	2,000	0%	6.15	7	400	2,000	0	-35%
056_03	Spring Creek	12	650	Geyer willow	35%	4.00	7	5,000	20,000	50%	3.08	7	5,000	20,000	0	0%
							Totals		58,000					68,000	10,000	

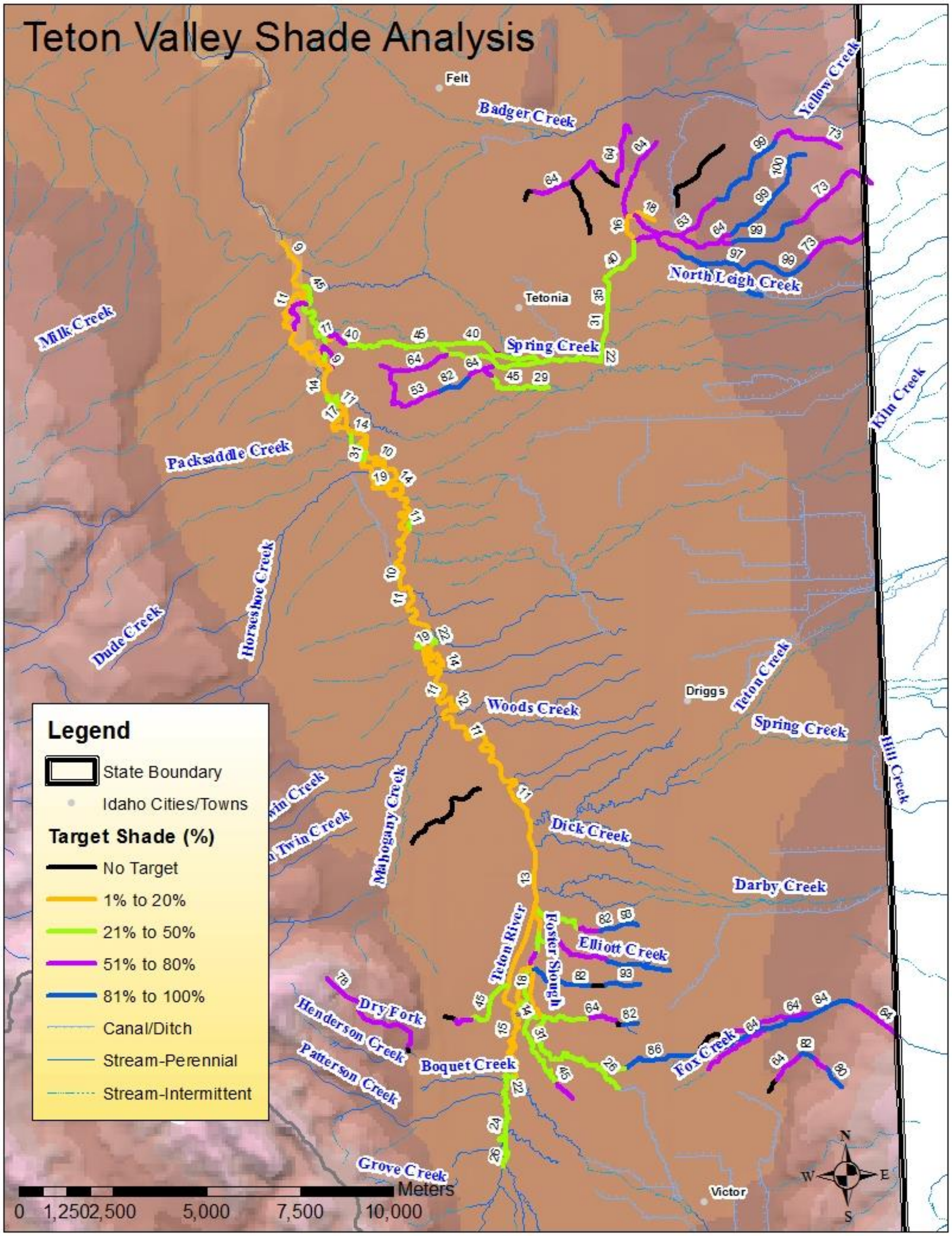

Figure 31. Target shade for the Teton River valley.

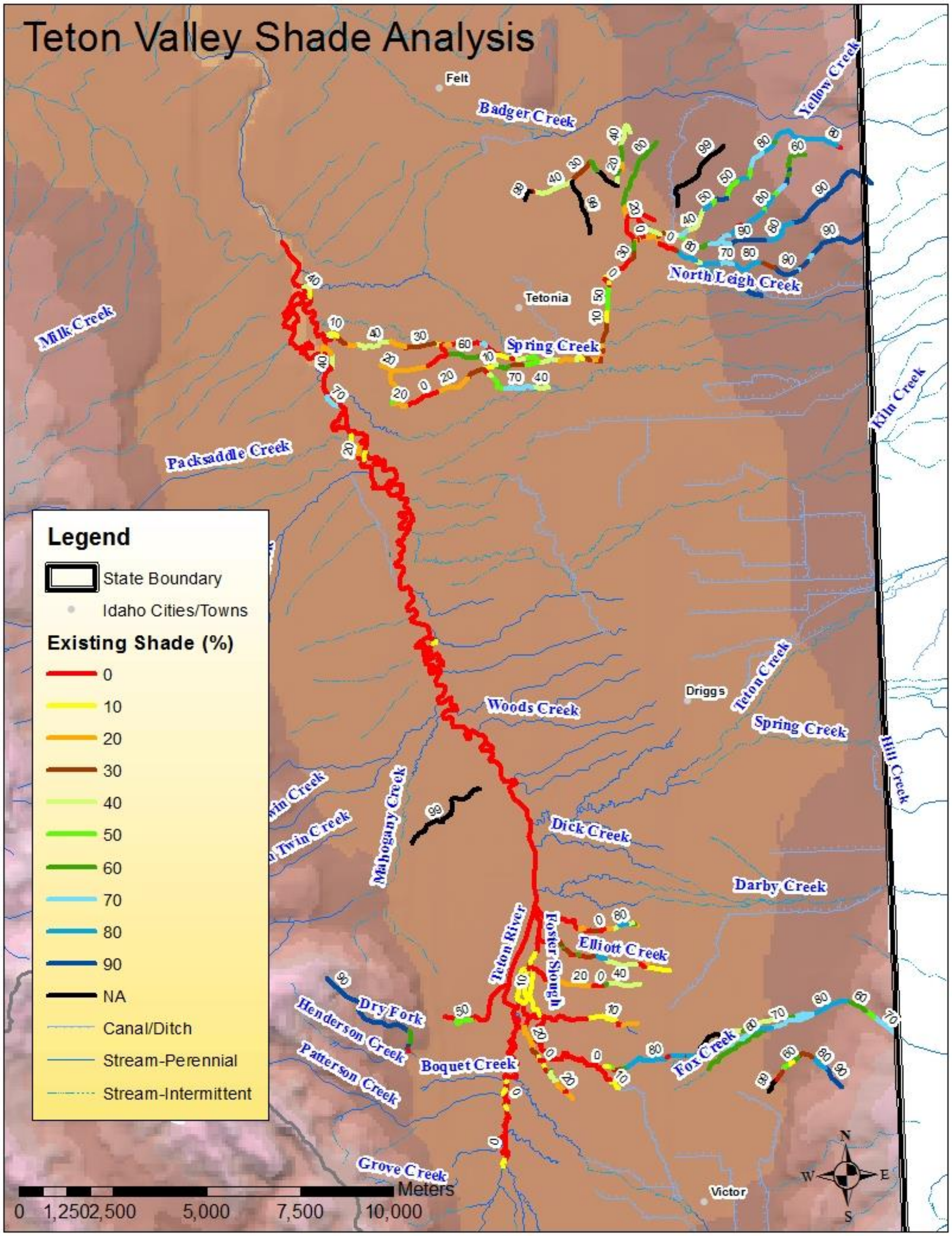

Figure 32. Existing shade estimated for the Teton River valley by aerial photo interpretation.

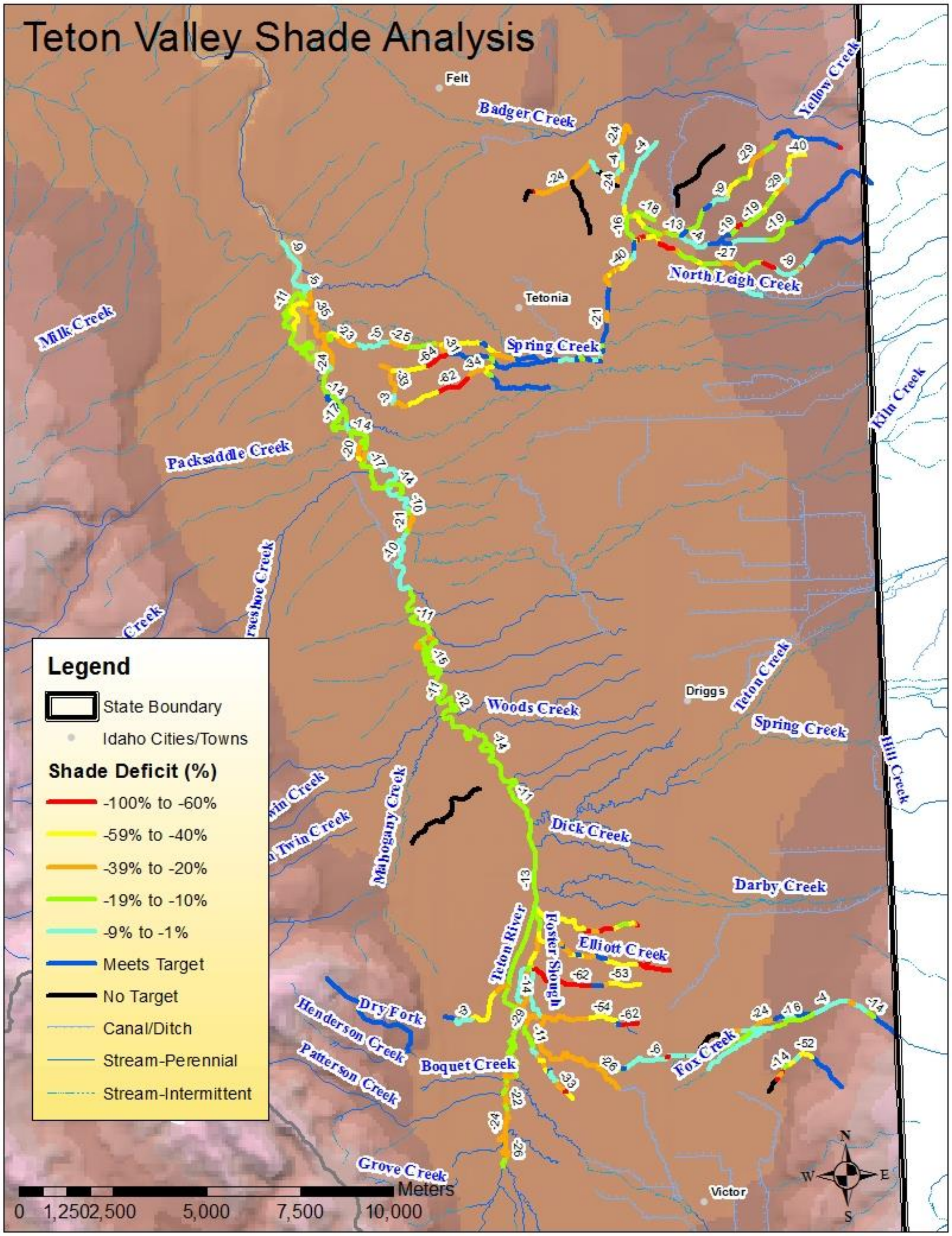

Figure 33. Shade deficit (difference between existing and target) for the Teton River valley.

5.1.4 Load Allocation

Because this TMDL is based on PNV, which is equivalent to background loading, the load allocation is essentially the desire to achieve background conditions. However, to reach that objective, load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Therefore, load allocations are stream segment specific and dependent on the target load for a given segment. Tables 17–26 show the target shade and corresponding target summer load. This target load (i.e., load capacity) is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL is dependent on background conditions for achieving water quality standards, all tributaries to the waters examined here need to be in natural conditions to prevent excess heat loads to the system.

Table 27 shows the total existing, target, and excess loads and the average lack of shade for each water body examined. The size of a stream influences the size of the excess load. Large streams have higher existing and target loads by virtue of their larger channel widths. Table 27 lists the tributaries in order of their excess loads, from highest to lowest. Therefore, large streams and rivers tend to be listed first and small tributaries last.

Although this TMDL analysis focuses on total solar loads, it is important to note that differences between existing and target shade, as depicted in the shade deficit figures (Figure 33), are the key to successfully restoring these waters to achieving water quality standards. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts. Each load analysis table contains a column that lists the lack of shade on the stream segment. This value is derived from subtracting target shade from existing shade for each segment. Thus, stream segments with the largest lack of shade are in the worst shape. The average lack of shade derived from the last column in each load analysis table is also listed in Table 27 and provides a general level of comparison among streams.

Table 27. Total solar loads and average lack of shade for all waters.

Water Body/ Assessment Unit	Total Existing Load	Total Target Load	Excess Load (% Reduction)	Average Lack of Shade (%)
		(kWh/day)		
Teton River (ID17040204SK026_04)	2,300,000	870,000	1,500,000 (65%)	-15%
Teton River (ID17040204SK020_04)	3,700,000	2.700,000	1,000,000 (27%)	-14%
Teton River (ID17040204SK017_04)	2,500,000	2,100,000	340,000 (14%)	-20%
Teton River Tributaries (ID17040204SK026_02)	1,000,000	820,000	220,000 (22%)	-32%
Fox Creek (ID17040204SK041_02)	520,000	340,000	180,000 (35%)	-23%
Spring Creek (ID17040204SK056_02)	420,000	240,000	180,000 (43%)	-27%
Teton River (ID17040204SK028_03)	310,000	220,000	89,000 (29%)	-20%
Spring Creek (ID17040204SK054_03)	520,000	470,000	57,000 (11%)	-19%
Spring Creek (ID17040204SK056_03)	68,000	58,000	10,000 (15%)	-25%
Fox Creek (ID17040204SK042_02)	23,000	31,000	0 (0%)	-6%

Note: Load data are rounded to two significant figures, which may present rounding errors.

With the exception of the upper AU of Fox Creek, all other AUs lacked shade and had excess solar loads. The three 4th-order AUs of the Teton River had the highest excess loads as would be expected since they are the largest and widest water bodies. Necessary percent reduction is high for AU ID17040204SK026_04 (Teton River), reflecting a possible over-widening of that reach; 2nd-order portions of Spring Creek and Fox Creek watersheds have large necessary percent reductions also. These areas tend to be cottonwood or aspen dominated and often lack shade due to tree removal for pasture or other impacts. The 3rd-order reaches lack shade as well, but not as much as upstream because willow communities tend to have lower shade requirements.

A certain amount of excess load is potentially created by the existing shade/target shade difference inherent in the load analysis. Because existing shade is reported as a 10% shade class and target shade a unique integer between 0 and 100%, there is usually a difference between the two. For example, say a particular stream segment has a target shade of 86% based on its vegetation type and natural bankfull width. If existing shade on that segment were at target level, it would be recorded as 80% in the load analysis because it falls into the 80% existing shade class. There is an automatic difference of 6%, which could be attributed to the margin of safety.

There are no known NPDES permitted point sources that would affect loading in temperature impaired streams, so no wasteload allocation is required. Should a point source be proposed that would have thermal consequences on these waters, background provisions in Idaho water quality standards addressing such discharges (IDAPA 58.01.02.200.09; IDAPA 58.01.02.401.01) should be involved (see Appendix A).

5.1.4.1 Margin of Safety

The margin of safety in this TMDL is considered implicit in the design. Because the target is essentially background conditions, loads (shade levels) are allocated to lands adjacent to these streams at natural background levels. Because shade levels are established at natural background or system potential levels, it is unrealistic to set shade targets at higher, or more conservative, levels. Additionally, existing shade levels are reduced to the next lower 10% shade class, which likely underestimates actual shade in the load analysis. Although the load analysis used in this TMDL involves gross estimations that are likely to have large variances, load allocations are applied to the stream and its riparian vegetation rather than specific nonpoint source activities and can be adjusted as more information is gathered from the stream environment.

5.1.4.2 Seasonal Variation

This TMDL is based on average summer loads. All loads have been calculated to be inclusive of the 6-month period from April through September. This time period is when the combination of increasing air and water temperatures coincide with increasing solar inputs and vegetative shade. The critical time periods are April through June when spring salmonid spawning occurs, July and August when maximum temperatures may exceed cold water aquatic life criteria, and September when fall salmonid spawning is most likely to be affected by higher temperatures. Water temperature is not likely to be a problem for beneficial uses outside of this time period because of cooler weather and lower sun angle.

5.2 Sediment TMDL

Sediment TMDLs have been developed in this document for 1 listed and 2 unlisted AUs. In addition, 3 AUs received updated TMDLs to account for the in-channel load.

5.2.1 Instream Water Quality Targets

To restore full support of beneficial uses that have been impaired by excess sediment, TMDL load allocations were determined using the best available data and field verification. DEQ collected streambank stability data and measurements in 2013. Calculations, maps, photographs, and field notes documenting this work and interpretations are provided in Appendix C.

5.2.1.1 Design Conditions

The 2003 TMDL contains a detailed discussion of subbasin conditions (DEQ 2003a,b). In summary, excess streambank erosion generally occurs during spring runoff when bankfull discharge occurs. Therefore, the stability characteristics of streambanks are measured at bankfull widths to determine the rate of excess erosion above natural background during peak flows. The same is true for the hillslope erosion that typically occurs during snowmelt and sporadically from rain events.

5.2.1.2 Target Selection

In the original Teton River TMDL, instream sediment targets were established at 80% streambank stability (DEQ 2003a,b). Methods for determining streambank stability from field observations are based on modified NRCS methods, Rosgen stream classification systems, and other applicable literature (Pfankuch 1975; Lohrey 1989; Rosgen 1996). The methods DEQ uses for determining bank stability are summarized in Appendix C.

5.2.1.3 Water Quality Monitoring Points

DEQ monitors streambank stability by conducting streambank erosion inventories (SEIs). When bioassessments indicate impairment and sediment is suspected as a pollutant, DEQ staff identify homogenous reaches of AUs to monitor for streambank stability by examining existing data and aerial photos. In the field, DEQ staff measure the length of the streambanks that are completely stable and the length, bank height, and condition of streambanks that are eroding. Recession rates (feet per year) of the eroding streambanks are determined in the field according to their condition. The percentage of stable and eroding streambanks are extrapolated to similar stream types in the AU. The bank erosion volume is then calculated using the following equation:

$$E = [AE \times RLR \times \_B]/2{,}000 \text{ (lb/ton)}$$

Where:

E = bank erosion over sampled stream reach (tons/year/sample reach)
AE = eroding area (square feet)
RLR = lateral recession rate (feet per year)
_B = bulk density of bank material (pounds per cubic feet)

This calculation for both the eroding and stable streambanks determines the load capacity at 80% streambank stability and the current load of the eroding areas. The load capacity is the natural, minimally erosive state one would expect of a covered, stable streambank. The current load is the tons of sediment per year calculated for the eroding streambanks at their current condition. The difference between the current load and the load capacity is the necessary load reduction. Since the sediment-impaired streams in the Teton River subbasin are impaired from nonpoint sources (i.e., streambank erosion), wasteload allocations are of limited assistance in improving stream quality to the natural background load capacity. Therefore, this TMDL allocates sediment load reductions that are necessary to meet the load capacities on a seasonal basis. Allocating load reductions is useful in identifying the erosion magnitude and timing needed to improve land management and the application of best management practices (BMPs).

DEQ conducted streambank erosion inventories at the locations indicated in Table 28. Three AUs in the Teton River subbasin exhibited impairment from sediment according to calculations from the field measurements and have received TMDLs and load allocations. Three main stem Teton River AUs have supplemental load information to be incorporated into the 2003 TMDL and on-going implementation plans. Although two AUs were examined to determine if sediment could be a factor limiting beneficial uses, these AUs did not have streambank erosion measurements indicative of a sediment impairment, nor were there significant sources of sediment or hillslope erosion processes identified that would lead to impairments. The streambank erosion inventory and sediment data are located in Appendix C. The AUs exhibiting sediment impairment should be monitored as watershed improvement projects proceed to confirm that streambanks are becoming more stable and salmonid spawning habitat is improving.

Table 28. Locations monitored for sediment trends in the Teton River subbasin.

Water Body	Assessment Unit Number	Monitoring Location
South Fork Moody Creek	ID17040204SK006_02	N 43.688634 W 111.550764
Fish Creek	ID17040204SK006_02	N 43.674712 W 111.55787
State Creek	ID17040204SK006_02	N 43.685779 W 111.557080
Warm Creek – Canyon Creek watershed	ID17040204SK011_02	N 43.746180 W 111.388209
Teton River – Cache Bridge to Highway 33 Bridge	ID17040204SK017_04	Entire AU
Teton River – Teton Creek to Cache Bridge	ID17040204SK020_04	Entire AU
Teton River – Trail Creek to Teton Creek	ID17040204SK026_04	Entire AU
Teton River – Warm and Drake Creeks confluence to Trail Creek	ID17040204SK028_03	Entire AU
Warm Creek – Trail Creek watershed (Pole Creek)	ID17040204SK034_02	N 43.555596 W 111.117973
Trail Creek – diversion to mouth	ID17040204SK035_03	Entire AU

5.2.2 Load Capacity

The sediment load capacity is the sediment loading rate at which beneficial uses are supported, and reductions are determined to meet those loads. The assumption is that this rate will be achieved at 80% streambank stability and possibly in combination with decreasing the streambank erosion rate. Monitoring will determine the individual load capacity for each impaired reach. Progress toward the load capacity will be made through trail and road maintenance, land management, and improvement of riparian vegetative cover and stream channel condition.

5.2.3 Estimates of Existing Pollutant Loads

To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads. Federal regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR §130.2(g)). The volume of eroding streambank at bankfull condition was calculated by measuring eroding bank height and length and evaluating the bank condition to estimate lateral recession rate during periods of high discharge, and accounting for the soil type erodibility. Detailed results are in Appendix C. As a result of these surveys and calculations, the current loads estimated for the Teton River subbasin are shown in Table 29. AU-specific notes detailing observations and interpretations are in Appendix B.

Table 29. Current annual sediment loads from nonpoint sources within the Teton River subbasin.

Assessment Unit	Current Load (tons/year)	Estimation Method	TMDL Required?
ID17040204SK006_02 South Fork Moody Creek – source to mouth	137[a]	Observed erosion rate calculated on target of 80% streambank stability	Yes
ID17040204SK006_02 South Fork Moody Creek– source to mouth (Fish Creek)	178[a]		
ID17040204SK006_02 South Fork Moody Creek – source to mouth (State Creek)	1,582[a]		
ID17040204SK011_02 Warm Creek – (Canyon Creek watershed)	0.7		No
ID17040204SK017_04 Teton River – Cache Bridge to Highway 33 Bridge	1,222		Yes
ID17040204SK020_04 Teton River – Teton Creek to Cache Bridge	934		Yes
ID17040204SK026_04 Teton River – Trail Creek to Teton Creek	166		Yes
ID17040204SK028_03 Teton River – Warm and Drake Creeks Confluence to Trail Creek	137		Yes
ID17040204SK034_02 Warm Creek – (Trail Creek watershed)	0.3		No
ID17040204SK035_02 Trail Creek – Diversion to mouth	854		Yes

[a] ID17040204SK006_02 South Fork Moody Creek – source to mouth had three sediment surveys; estimations of loading were developed for representative stream lengths and location of confluences.

5.2.4 Load Allocation

The load capacity is the natural, minimally erosive state in a vegetated and stable streambank. The load capacity is the natural background condition, currently targeted to be 80% stable streambanks. The current load is the tons of sediment per year calculated for the eroding streambanks at their current condition based on field measurements. The difference between the current load and the load capacity is the necessary load reduction. The load allocation is the amount of sediment that can be discharged to the stream and still meet the water quality standards and a 10% margin of safety. However, as sediment in these AUs are solely from nonpoint sources, the allocation required to meet load capacity will be based on the necessary load reductions, rather than the allocation of allowable loads. This method better directs the implementation to times of greatest loads. Table 30 lists the sediment reductions necessary to achieve the load capacity of the AU.

No NPDES-permitted facilities discharge directly into any sediment-impaired waters within the Teton River subbasin, so no sediment wasteload allocations are necessary. For other active dischargers, any potential sediment load is assumed to be part of the nonpoint source load (Table 36).

Table 30. Current loads, load capacity, and necessary reductions from nonpoint sources in the Teton River subbasin.

AU (ID17040204)	Segment	Current Load (tons/year)	Load Capacity (tons/year)	Margin of Safety (tons/year)	Load Allocation (tons/ year)	Load Reduction (tons/year)	Percent Reduction
SK006_02	South Fork Moody Creek	137	144	14	130	7	5%
	Fish Creek	1,582	86	9	77	1505	95%
	State Creek	178	14	1	13	165	93%
SK011_02	Warm Creek – (Canyon Creek watershed)	0.7	13	1	12	n/a	n/a
SK017_04	Teton River	1222	450	45	405	817	64%
SK020_04	Teton River	934	401	40	361	573	59%
SK026_04	Teton River	166	63	6	57	109	63%
SK028_03	Teton River	137	51	5	46	91	64%
SK034_02	Warm Creek – (Trail Creek watershed)	0.3	7	1	6	n/a	n/a
SK035_03	Trail Creek	854	127	13	114	740	87%

There are six AUs requiring load reductions that are either newly developed in this TMDL or supplemental. Three AUs have supplemental information deemed necessary for effective implementation: main stem Teton River AUs ID17040204SK026_04, 020_04, and 017_04, all with approved TMDLs (DEQ 2003a). However, the 2003 TMDL did not estimate a streambank and substrate load within the main stem in its allocation process. Monitoring in 2013 found a need to supplement the TMDL by adding in another loading source, which is presumed to be additive to the loads already in place and load reductions being implemented. While these AUs have not yet reached the goals set in the 2003 TMDL, actions and management changes are being applied. The one caveat of the main stem sediment loads from the substrate is that the actual source may have been accounted for as an upland source or upstream bank erosion, which may lead to allocating these loads and reductions twice. However, this possibility is deemed to add to the conservative nature of the process. The reductions and allocations in the 2003 TMDL are still in place with the expectation of land-use improvements continuing to take place.

Three AUs require newly developed load reductions (Table 30), one of which (ID17040204SK006_02) was divided into two sub-watersheds for calculating the annual hydrograph, as these drainage areas are discontinuous. This AU is inclusive of several tributaries; Fish Creek and State Creek are continuous within the AU, while South Fork Moody Creek is examined separately for discharges. Erosion rate estimates and load calculations are based on multiple monitoring locations in each stream channel, with the sum of those calculated loads used to identify the overall sediment load capacity and reduction required for the AU. Data from both sub-watersheds are included but the allocation and load reductions are representative of the AU as a whole.

Peak discharges in these sediment-impaired streams occur during spring snowmelt, which may occur in late spring or early summer. The largest proportion of sediment is eroded from the streambanks during spring discharge, when the stream power is greatest to mobilize sediment.

The daily sediment load is allocated based on discharge. Flow duration intervals summarize the cumulative frequency of historic discharge data over the period of record. No gages are located in the AUs of concern; therefore, USGS StreamStats was used to estimate monthly discharges (*http://water.usgs.gov/osw/streamstats/idaho.html*).

EPA describes an approach for using load duration curves in developing TMDLs and specifies calculating the cumulative frequency distribution using discharge records (EPA 2007). Extrapolations from this EPA guidance were used to adapt the data from the USGS StreamStats discharge estimations. The 0–20th percentile discharges are designated as high discharges, 20th–50th percentiles as midrange discharges, 50th–80th as dry conditions, and 80th–100th as low flow conditions.

Results of the flow duration interval method for allocating sediment load reductions are summarized in Table 31. Details about methods and assumptions used in calculating and allocating the load reductions follow.

Table 31. Sediment load allocations based on flow.

Assessment Unit	Load Allocation (tons/year)	Load Allocation
ID17040204SK006_02, South Fork Moody Creek—source to mouth (Fish and State Creek)	90	High Flow—0.85 tons/day Mid Flow—0.14 tons/day Dry Conditions—0.08 tons/day Low Flow—0.05 tons/day
ID17040204SK006_02, South Fork Moody Creek—source to mouth (South Fork Moody Creek)	130	High Flow—1.23 tons/day Mid Flow—0.2 tons/day Dry Conditions—0.12 tons/day Low Flow—0.07 tons/day
ID17040204SK028_03, Teton River—confluence Warm and Drake Creeks to Trail Creek	46	High Flow—0.42 tons/day Mid Flow—0.07 tons/day Dry Conditions—0.04 tons/day Low Flow—0.04 tons/day
ID17040204SK035_03, Trail Creek—diversion to mouth	114	High Flow—1.16 tons/day Mid Flow—0.27 tons/day Dry Conditions—0 tons/day Low Flow—0 tons/day

Note: Load allocations for Fish and State Creek were combined due to flow data availability.

Calculations:

The following flow duration intervals were used to express the sediment load allocation in “tons/day” (Figure 34 through Figure 37). Since the load allocations in Table 30 were calculated in terms of tons/year with no specific flow intervals in mind, they need to be allocated accordingly and converted to a daily load. The proportion of sediment load for each flow interval and the proportion of days in a year need to be considered so that each flow interval can receive its own daily load allocation.

The mid-point value within each flow interval was calculated to provide representative values. The mid-point values of each interval were summed to represent the total flow of the stream, and the percentage of the total flow for each interval mid-point was calculated.

Since the flow duration figures represent flow intervals in terms of percentages, the percentage of duration of each interval can be multiplied by the number of days in a year to determine the length of each flow interval in days.

Example:

Using Figure 34, the flow duration interval graph for Fish and State Creeks:

We calculated the mid-point value of each flow interval:

High flows: 5.7 to 31 cfs = (5.7 cfs + 31 cfs)/2 = **18.35 cfs**
Mid-range flows: 3.5 to 5.6 cfs = (3.5 cfs + 5.6 cfs)/2 = **4.55 cfs**
Dry conditions: 2.1 to 3.4 cfs = (2.1 cfs + 3.4 cfs)/2 = **2.75 cfs**
Low flows: 0 to 2 cfs = (0 cfs + 1 cfs)/2 = **1.0 cfs**

Total Flow = Sum of each interval's mid-point flow (18.4 + 4.6 + 2.8 + 1) = **26.65 cfs**

The high flow interval is (18.35 cfs/26.65 cfs)*100 or 69% of the total flow, which is assumed to be the percentage of sediment load transported during flows of this magnitude. Mid flows are 17%, dry conditions are 10%, and low flows are 4% of the total flow.

The above percentages of total flow can be multiplied by the load allocation to obtain the proportion of the load that is transported within each flow interval, which is then divided by the number of days in the flow interval to convert the load allocation into tons per day.

To obtain the number of days in each flow interval, the percent of flow duration for each interval is multiplied by the number of days in a year:
High flows represent 20% of the flow duration per year (0.2*365 days) = 73 days.
Mid flows are 30% (109.5 days), dry conditions are 30% (109.5 days), and low flows are 20% (73 days).

To calculate the distribution of the load allocation for each flow interval:
(% total load * load allocation)/(number of days in flow interval) = Load allocation per day for the given flow interval.

High flows: (0.69*90 tons/year)/73 days = 0.85 tons/day.

These calculation methods were used for each of the AUs requiring new sediment TMDLs.

In AU ID17040204SK006_02 South Fork Moody Creek – source to mouth, allocation of the load reduction using the StreamStats modified flow duration curve were developed for Fish and State Creeks separately from South Fork Moody Creek. The Fish and State Creeks portion of the AU was estimated to have a load capacity of 100 tons/year. Flow duration intervals of the monthly discharge estimations were developed for Fish and State Creek (Figure 34).

- High discharges (0–20th percentile) occur between 5.7 and 31 cfs; mid-point = 18.35 cfs.
- Middle range discharges (20th–50th percentile) occur between 3.5 and 5.6 cfs; mid-point = 4.55 cfs.
- Dry conditions (50th–80th percentile) occur between 2.1 and 3.4 cfs; mid-point = 2.75 cfs.
- Low flows (80th–100th percentile) occur between 0 and 2.0 cfs; mid-point = 1.0 cfs.

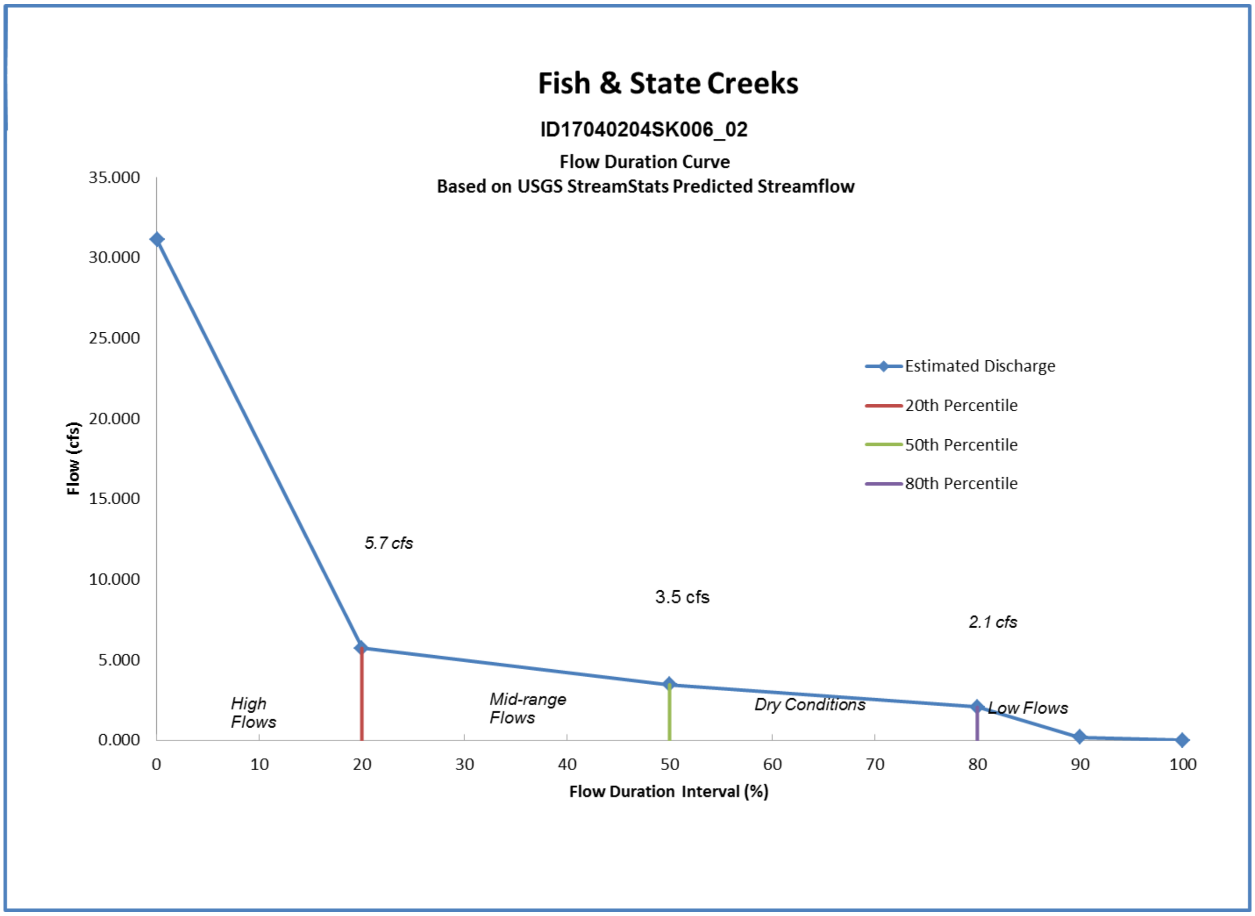

Figure 34. Flow duration curve for the ungaged stream segment in South Fork Moody Creek (State and Fish Creeks) (ID17040204SK006_02).

In AU ID17040204SK006_02, South Fork Moody Creek – source to mouth, the South Fork Moody Creek portion of the AU was estimated to have a load capacity of 144 tons/year. Flow duration intervals of the monthly discharge estimations were developed for South Fork Moody Creek (Figure 35).

- High discharges (0–20th percentile) occur between 10 and 55 cfs; mid-point = 32.5 cfs.

- Middle range discharges (20th–50th percentile) occur between 6.0 and 9.9 cfs; mid-point = 7.95 cfs.
- Dry conditions (50th–80th percentile) occur between 3.5 and 5.9 cfs; mid-point = 4.7 cfs.
- Low flows (80th–100th percentile) occur between 0.5 and 3.4 cfs; mid-point = 1.95 cfs.

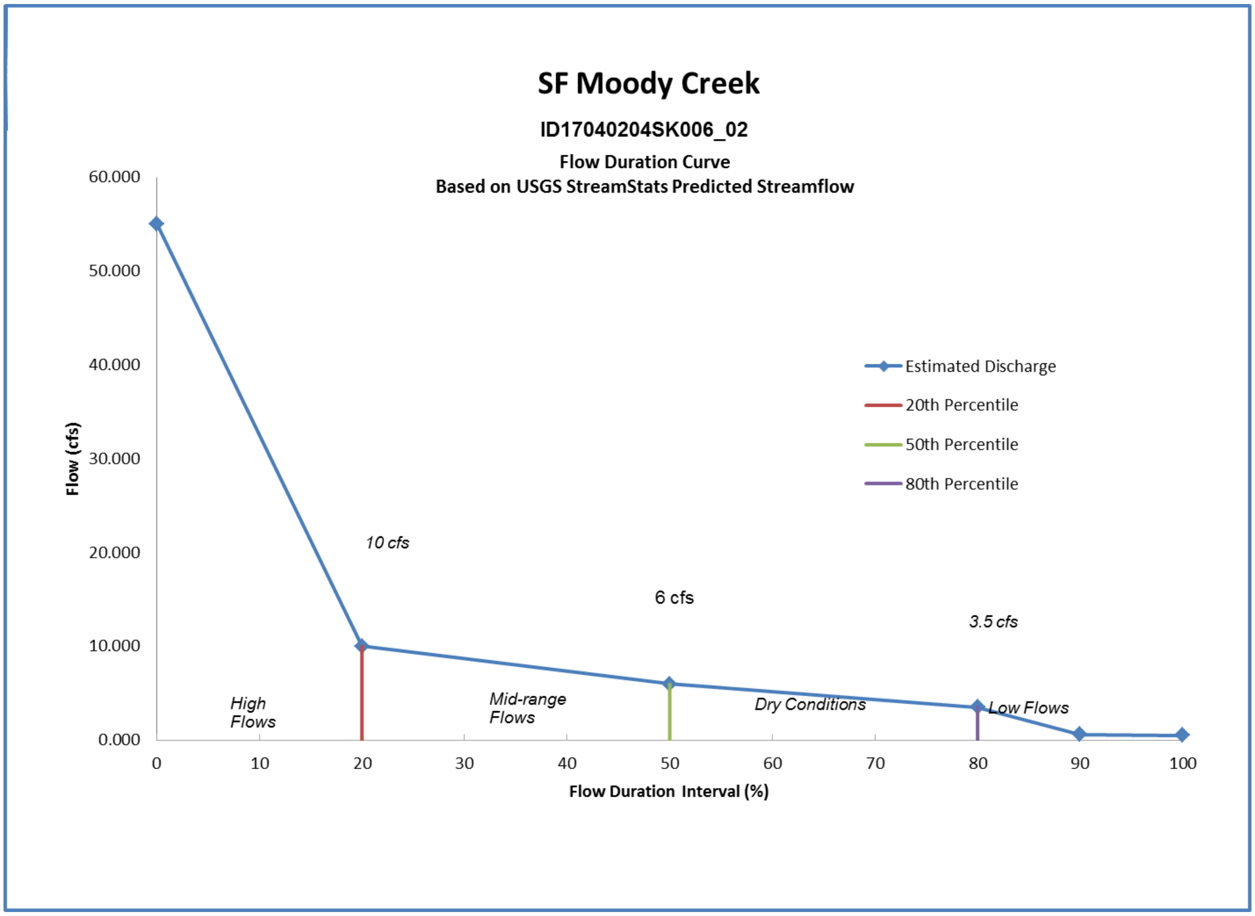

Figure 35. Flow duration curve for the ungaged stream segment in South Fork Moody Creek (ID17040204SK006_02).

In AU ID17040204SKL028_03, allocation of the load reduction using the StreamStats modified flow duration curve was developed for the Teton River. Flow duration intervals of the monthly discharge estimations were developed for Teton River (Figure 36).

- High discharges (0–20th percentile) occur between 33 and 171 cfs; mid-point = 102 cfs.
- Middle range discharges (20th–50th percentile) occur between 19 and 33 cfs; mid-point = 26 cfs.
- Dry conditions (50th–80th percentile) occur between 11 and 19 cfs; mid-point = 15 cfs.
- Low flows (80th–100th percentile) occur between 10 and 11 cfs; mid-point = 10.5 cfs.

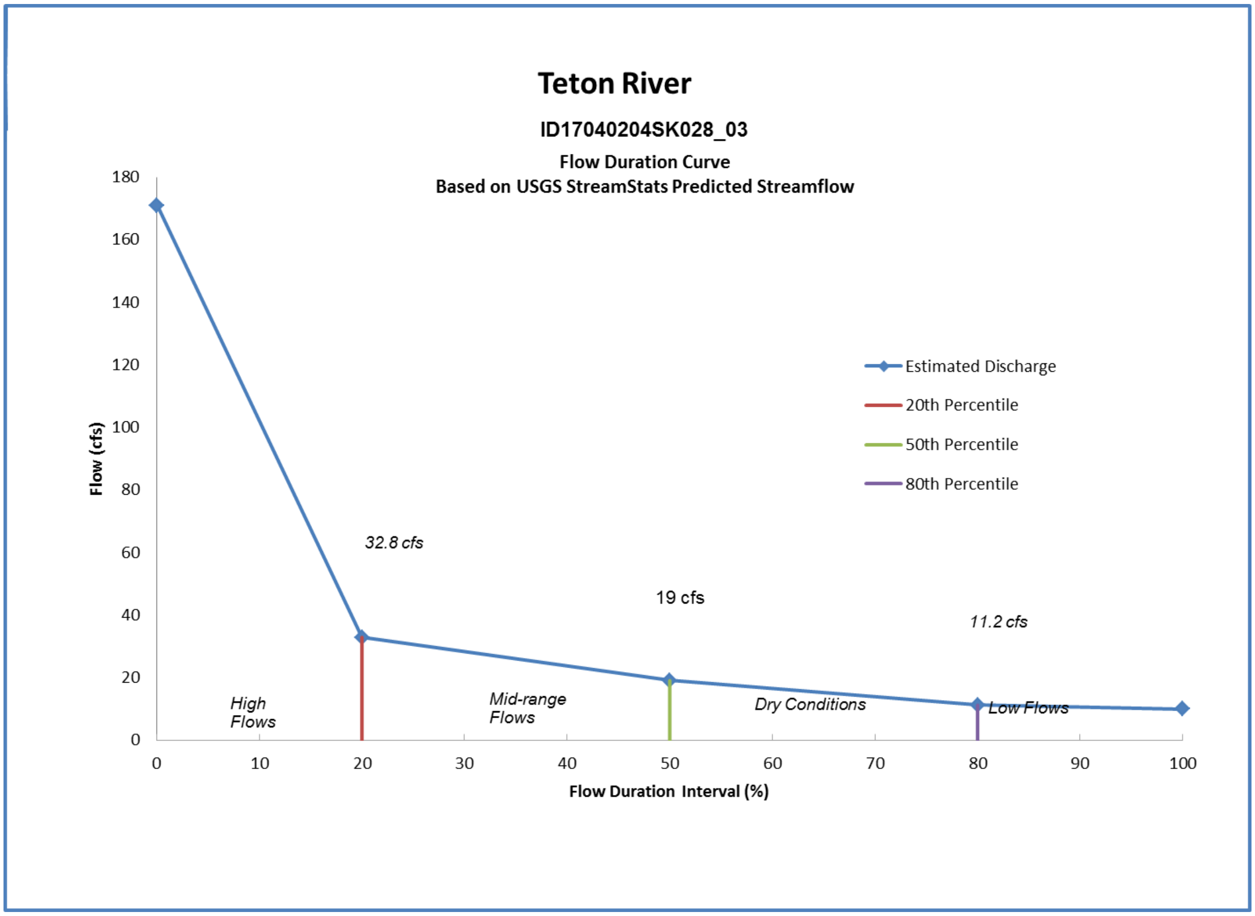

Figure 36. Flow duration curve for the ungaged stream segment in the Teton River (AU ID17040204SKL028_03).

In AU ID17040204SK035_03, Trail Creek – source to mouth, allocation of the load reduction using the StreamStats modified flow duration curve was developed for Trail Creek. Flow duration intervals of the monthly discharge estimations were developed for Trail Creek (Figure 37).

- High discharges (0–20th percentile) occur between 48 and 86 cfs; mid-point = 67 cfs.
- Middle range discharges (20th–50th percentile) occur between 0 and 48 cfs; mid-point = 24 cfs.
- Dry conditions (50th–100th percentile) occur at 0 cfs.

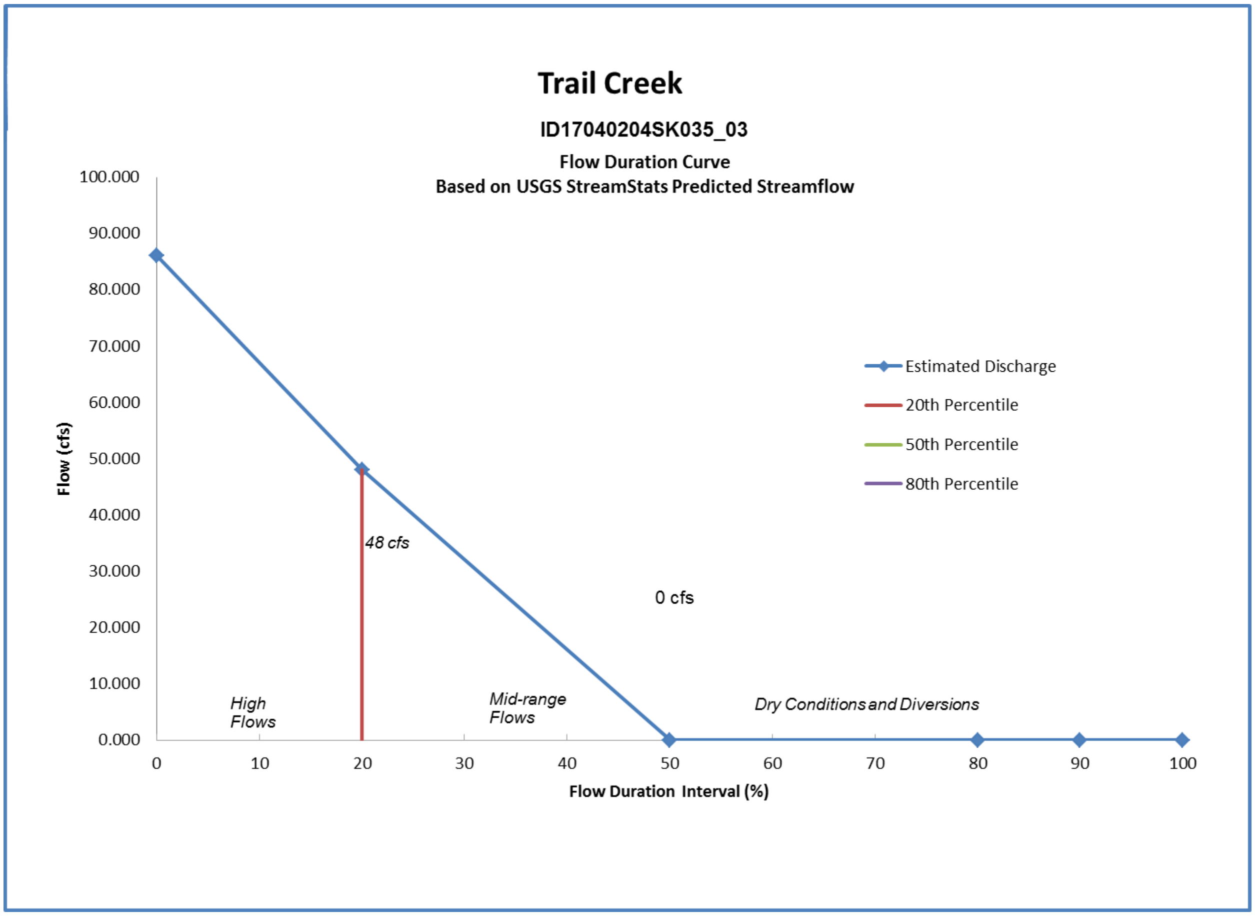

Figure 37. Flow duration curve for the ungaged stream segment in Trail Creek (ID17040204SK035_03).

5.2.4.1 Margin of Safety

- A 10% MOS was added to the load allocation to account for variability.
- The SEI is a conservative method using assumptions of bankfull discharges that mobilize the banks and substrate. Since bankfull discharges are typically considered to have a 1.5-year recurrence interval, assumptions of bankfull discharges on an annual basis and associated erosion add to the conservative nature of the allocation process.

5.2.4.2 Seasonal Variation

Peak discharges in these sediment-impaired streams occur during spring snowmelt. The largest proportion of sediment is eroded from the streambanks during spring discharge. The daily sediment load is allocated based on this discharge-dominated curve.

5.2.4.3 Natural Background

Sediment load allocations are estimated targets in the process of improving water quality that promotes the beneficial uses of cold water aquatic life and/or salmonid spawning as fully supported. The load capacity is the natural, minimally erosive state in a vegetated and stable streambank. The load capacity is the natural background condition, currently targeted to be 80% stable streambanks. While sediment may be the causal factor for impairment, until the stream meets the designated beneficial uses, typically determined by passing BURP scores, any implementation and load reduction cannot be deemed successful.

5.3 Bacteria TMDL

Bacteria TMDLs have been developed in this document for 3 listed AUs in the subbasin. An additional 2 listed AUs were monitored and found to be meeting bacteria water quality standards. These 2 AUs are recommended for delisting in the next Integrated Report.

5.3.1 Instream Water Quality Targets

Instream water quality targets for the Category 5 bacteria (*E. coli*/fecal coliform) listed waters in the Teton River subbasin were set from the Idaho water quality standards. The State of Idaho water quality standards prescribe *E. coli* criteria for both primary and secondary contact recreation. To support the beneficial use of primary or secondary contact recreation, a geometric mean of 126 organisms/100 mL for 5 samples collected every 3 to 7 days within a 30-day period is required to determine exceedance of the standard. An *E. coli* single instantaneous sample of 576 organisms/100 mL for secondary contact recreation is not a violation of the water quality standards but acts as a trigger for more monitoring (IDAPA 58.01.02.251.01).

Monitoring in Warm Creek AU ID17040204SK011_02 (Canyon Creek watershed) was conducted to support correcting the Integrated Report, as there are two Warm Creeks in the Teton River subbasin and the listing data used were incorrectly examined from the other creek (ID17040204SK034_02). See map in section 4.2 (Figure 20). AU ID17040204SK011_02 should have been assessed based on a 40 organisms/100 mL sample in 1999 at the BURP site 1997SIDFL063 (see Appendix G and Appendix B for more details). The follow-up monitoring in 2011 calculated a geometric mean of 44 organisms/100 mL (Appendix G, Appendix B, Table 32), confirming the incorrect listing based on duplicative stream names.

Warm Creek AU ID17040204SK034_02 (Trail Creek watershed) was found to be in compliance with the bacteria standard to support secondary contact recreation. Since the identification of exceedances in 1999, there have been multiple land-use changes—primarily from rural to urbanized, along with exclosure fencing—that have led to meeting the standard in 2011 with a calculated a geometric mean of 51 organisms/100 mL (Appendix G, Appendix B, Table 32).

The Driggs Springs Complex (ID17040204SK049_02) and Woods Creek (ID17040204SK050_02) AUs are being associated together for *E. coli* monitoring and TMDL load allocations as the creek and complex are hydrologically connected in a series of peat wetlands with similar beneficial uses and land-use issues (see section 5.3.4 for more information).

5.3.1.1 Design Conditions

Bacteria affect streams throughout the summer months and into the fall during baseflow conditions. The critical period for recreational beneficial use is from May through October. With no known sources of human-caused bacteria loading, it is assumed that the observed *E. coli* levels are caused by a combination of wildlife, waterfowl, and livestock. To protect the beneficial use, the design conditions include the critical period when the bacteria contamination is most likely to occur.

5.3.1.2 Target Selection

The State of Idaho water quality standards prescribe *E. coli* criteria for recreation beneficial uses. To support the beneficial use of secondary contact recreation, a geometric mean of 126 organisms/100 mL for 5 samples collected every 3 to 7 days within a 30-day period is required to determine exceedance of the standard.

5.3.1.3 Water Quality Monitoring Points

The Teton River subbasin AUs on the Category 5 list for *E. coli*/fecal coliform were monitored for compliance with the *E. coli* bacteria secondary contact recreation criteria at the locations where exceedances were last identified and where future monitoring should occur (as necessary):

- North Fork Moody Creek at 1995SIDFB083: N 43.697636° W -111.529088°
- Warm Creek (Canyon Creek watershed) at 1997SIDFL018: N 43.78097° W -111.444962°
- Warm Creek (Trail Creek watershed) at 1997SIDFL063: N 43.591902° W -111.160776°
- Woods Creek and Driggs Springs Complex at 1997SIDFL071: N 44.719947° W -111.173028°

5.3.2 Load Capacity

In bacteria TMDLs, the water quality standard is the load capacity of a system. Because the bacteria target is in colony forming units (cfu) per 100mL, we have converted it to a daily load by using the average monthly flow for the month of sampling and a conversion factor that converts mL per second to cubic feet per day:

> LC (cfu/day) = WQS (cfu/100 mL) * flow (cfs) * unit conversion factor where,
> unit conversion factor = 24,465,525 ml*s / ft3*day.

5.3.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR 130.2(g)).

Monthly sampling was initiated in 2010 to determine seasonality in the loads as part of a study not designed to meet Idaho water quality standards and sampling requirements. No consistent trends were identified that could be attributed land uses other than those identified within section 5.3. None of these single samples are compliant with Idaho water quality standards. Therefore, in 2011 monitoring was initiated to examine for meeting the 5-sample geometric mean (Table 32). Monitoring in 2011 found *E. coli* geometric mean exceedances in North Fork Moody Creek (818 organisms /100 mL). Historic monitoring in 1999 found *E. coli* geometric mean exceedances in the North Fork Moody Creek AU at 704 organisms/100 mL. Woods Creek and the Driggs Springs complex were also both found to be exceeding the standard (Table 32) of 126 organisms /100 mL.

Table 32. Bacteria monitoring results in the Teton River subbasin.

AU	Stream	Site ID	Date	*E. coli* (organisms/100 mL)
ID17040204SK007_02	Sheep Creek	1997SIDFL013	Aug 1999	704 geomean[a]
	North Fork Moody Creek	1997SIDFM011	June 2010	53 single sample
			July 2010	326 single sample
			Aug 2010	1554 single sample
			Sep 2010	65 single sample
			Sep 2011	818 geomean[a]
ID17040204SK011_02	Warm Creek (Canyon)	1997SIDFL018	Aug 1999	40 single sample
			June 2010	27 single sample
			July 2010	128 single sample
			Aug 2010	518 single sample
			Sep 2010	196 single sample
			Sep 2011	44 geomean[a]
ID17040204SK034_02	Warm Creek (Trail)	1997SIDFL063	Aug 1999	541 geomean[a]
			June 2010	194 single sample
			July 2010	123 single sample
			Aug 2010	771 single sample
			Sep 2010	231 single sample
			Sep 2011	51 geomean[a]
ID17040204SK049_02 ID17040204SK050_02	Driggs Springs Complex and Woods Creek	1997SIDFL071	June 2010	60 single sample
			July 2010	921 single sample
			Aug 2010	38 single sample
			Sep 2010	921 single sample
			Sep 2011	191 geomean[a]

[a] The "geomean" is the geometric mean calculated from 5 samples collected in a 30-day period every 3–7 days.

5.3.4 Load Allocation

Five AUs are listed for *E. coli* bacteria (or fecal coliform) in the 2012 Integrated Report and had 5-sample geometric means calculated from 2011 monitoring data. Three AUs were found to be exceeding the water quality standard for bacteria. Historically, Idaho monitored for fecal coliform, but the standard changed in 2006 to *E. coli*, a common intestinal bacteria found in warm-blooded animals and therefore considered more directly pathogenic to humans. Loads and allocations for AUs requiring TMDLs are in Table 34. Since the bacteria target level is the WQS or 126 cfu/100mL, we convert that target to a load capacity on a daily basis. Flow values for the month of September are represented using 50% flow duration, which was estimated using the USGS StreamStats delineation tool. September values were used since the most recent *E. coli* sampling took place during September 2011 (Table 32). The September 50% flow duration values for the three AUs requiring bacteria TMDLs are: Sheep Creek/North Fork Moody Creek (SK007_02) = 1.68 cfs; Driggs Springs Complex (SK049_02) = 0.91 cfs; and Woods Creek (SK050_02) = 2.28 cfs (Table 33).

Table 33. Drainage area and average September monthly flows for AUs requiring bacteria load allocations.

Parameter	Sheep Creek/North Moody Creek	Driggs Spring Complex	Woods Creek
Drainage area	13.68 mi^2	1.75 mi^2	4.19 mi^2
September 50% Duration	1.68 cfs	0.91 cfs	2.28 cfs

These 50% September flow duration values were used to calculate the flow-based load capacity. We then determined the load allocation by subtracting a 10% MOS from the load capacity as follows, using Sheep Creek/North Fork Moody Creek (ID17040204SK007_02) as an example:

LA = 126 cfu/100mL x 1.68 cfs x 24,465,525 mL*s/cu. ft.*day = 5.18 x 10^9 cfu/day x 90% (MOS removal) = 4.66 x 10^9 cfu/day

The current load in September in Sheep Creek/North Fork Moody Creek was based on a sampled geomean of 818 cfu/100mL (Table 32) and is calculated as shown below. Thus, the excess load is the current load minus the load allocation, resulting in a needed 86% reduction in order to achieve the load allocation:

Current Load = 818 cfu/100mL x 1.68 cfs x 24,465,525 mL*s/cu. ft.*day = 3.36 x 10^{10} cfu/day

The calculated LAs, current loads, and necessary reductions for the three AUs are listed below in Table 34.

Table 34. Nonpoint source bacteria load allocations for Teton River subbasin.

Assessment Unit	Load Allocation	Current Load	Excess Load	Percent Reduction
ID17040204SK007_02	4.66 x 10^9	3.36 x 10^{10}	2.89 x 10^{10}	86%
ID17040204SK049_02	2.52 x 10^9	4.25 x 10^9	1.73 x 10^9	41%
ID17040204SK050_02	6.33 x 10^9	1.07 x 10^{10}	4.32 x 10^9	40%

Note: All load units are cfu/day.

Based on USGS 1979 topographic maps, the Woods Creek/Driggs Springs complex was a wetland/marshy area without definitive natural breaks, particularly in the headwaters area as indicated in the 2011 USGS topographic map (Figure 38) and the Google map (Figure 39).

Multiple areas in these AUs appear to be interconnected either through surface or ground water. As a result of this interpretation, *E. coli* geometric mean sampling only took place in the Woods Creek AU (SK050_02) with the intention of also using these values to represent the Driggs Springs AU (SK049_02). These AUs are downgradient of the Driggs WWTP, and reports in 2004 and 2006 indicate that the land use and hydrology support the reasonableness of using the Woods Creek geometric mean value for Driggs Springs to yield two separate TMDLs. In future analysis and assessments, however, sampling should take place within both AUs in order to verify that they experience similar bacteria loading.

A 2006 report by Lyn Benjamin of FTR found that over two-thirds of the *E. coli* (68%) was genetically typed to *E. coli* found in scat from wildlife sources. Of those wildlife sources, approximately half (or 36% of the total) were related to avian and/or waterfowl sources. Only 30% of the total was related to human/domestic sources (i.e., cattle, dogs, cats) and 2% to an unknown source (Benjamin 2006). This 2006 study was to complement the work by DEQ in 2004 examining the concerns of *E. coli* prior to renewing the NPDES permit for the Driggs WWTP and future improvements to the WWTP. These WWTP improvements have been completed, which has reduced *E. coli* concerns. Data from WWTP monthly monitoring reports in 2013–2015 indicate the WWTP is at/near (and often below) the permitted discharges for *E. coli*.

While the standard is 126 organisms/100 mL, non-WWTP discharge monitoring locations in 2003–2004 exceeded that target, often near 1,000 organisms/100 mL or above. Based on the 2006 findings of wildlife sources, the exceedance of the 126 organisms/100 mL standard was potentially enhanced as a result of these additional inputs. This scenario is probable as the wetlands along the Teton River are prime bird habitat, including mating and nesting pairs of Sandhill Cranes, and serve as resting/grouping areas in the fall for those birds prior to migration.

Since the discharges of all these streams are minor when compared to the Teton River, these AUs are not expected to be significant sources to the river and should be adequately diluted within a reasonable distance with no adverse impacts on primary contact recreation.

Future monitoring to determine impacts should occur at locations not directly downstream of the WWTP; outfall data are available and upgrades are expected to meet NPDES permits levels. Access point selection and extra care to not disturb the silty peat marsh substrate prior to sampling is highly recommended.

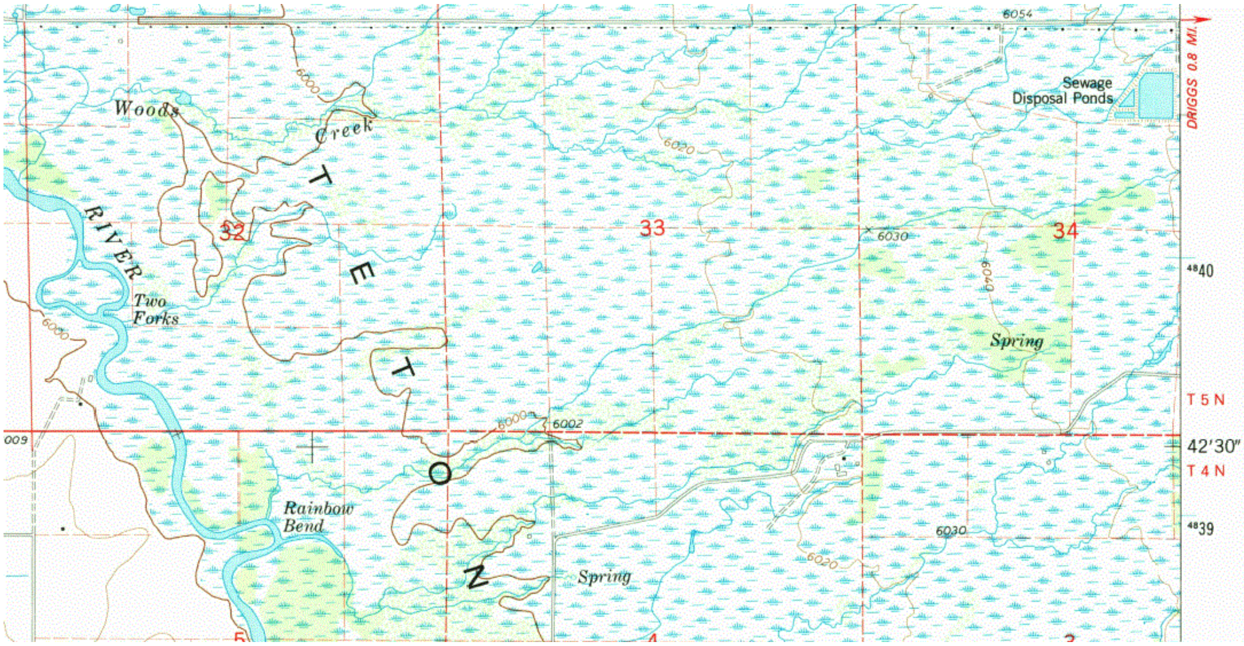

Figure 38. Woods Creek section of USGS 7.5-minute Driggs topographic map indicating wetlands.

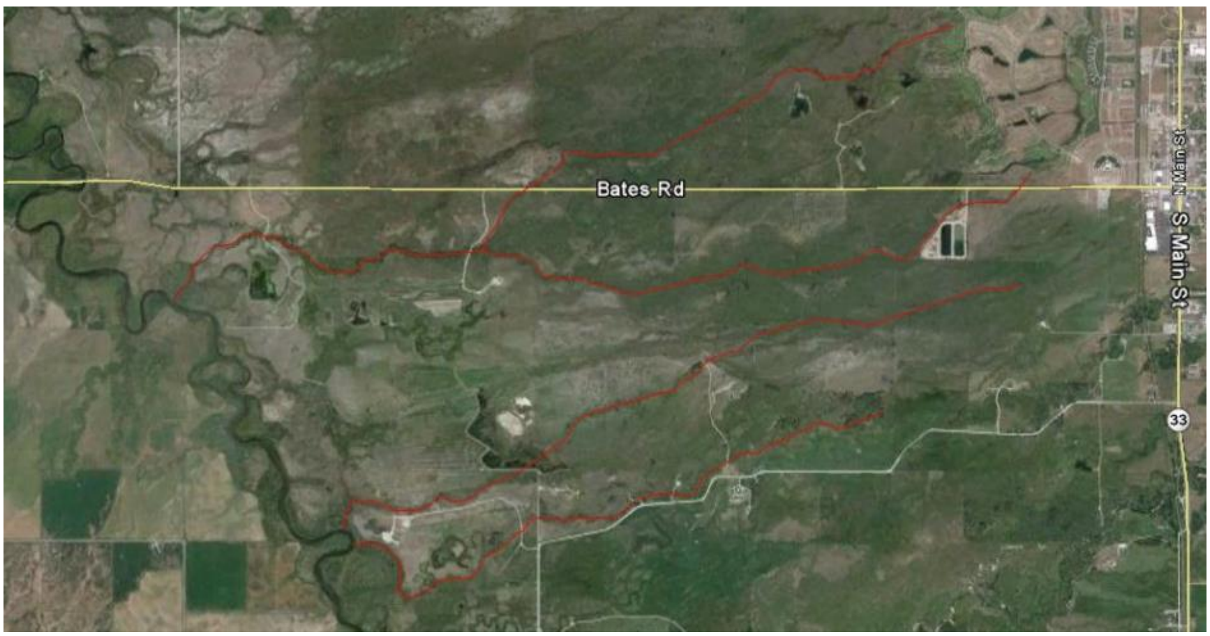

Figure 39. Woods Creek and Driggs Springs complex listed AUs.

North Fork Moody Creek (ID17040204SK007_02) is believed to be impacted primarily by grazing in the late summer months when range is accessible, which is compounded by the general habitat being suitable for elk, deer, and moose. The TMDL requires an 86% load reduction. The 2013 grazing allotment prescribed improvements and management practices to prevent overgrazing in the riparian areas. Improvements include the Spori Canyon water supply headbox and pipe. It is expected that improved management and reviews by the USFS should lead to meeting the bacteria standard.

5.3.5 Wasteload Allocation

The *E. coli* wasteload allocations are based on a bacteria concentration of 126 cfu/100 mL, collected as a 5-sample geometric mean over 30 days. The same target concentrations apply to every NPDES-permitted facility, which is a strategy that provides a clear regulatory system for permitting. Since this TMDL is concentration based, the wasteload allocations (WLA) are based on the design flow. The equation below provides the conversion of the *E. coli* WQS from cfu/100 mL to cfu/day/mgd (i.e., daily load):

$$126\ cfu/100\ mL\ x\ \frac{3.785\ L/gal\ x\ 10^6 gal/million\ gal}{0.1\ L/100\ mL\ x\ 10^9} = 4.76\ x\ 10^9\ cfu/day/mgd$$

The resulting number is multiplied by the design flow of the facility to obtain the E. *coli* WLA. The equation includes the removal of a 10% margin of safety:

E. coli WLA (in 10^9 cfu/day) = $Q \times 4.76 \times 0.9$ (MOS removal)

Where Q is the design flow of the facility in **million gallons per day** (mgd). For the City of Driggs WWTP, the design flow is 0.6 mgd.

If the design flow were to increase, then the wasteload allocation would correspondingly increase based on the equation above. Table 35 outlines the design flow and wasteload allocation for the Driggs WWTP. The wasteload allocation, 2.57 x 10^9 cfu/day, is equivalent to a monthly geometric mean of 68 cfu/100 mL. The facility is presently meeting this wasteload allocation based on recent discharge monitoring reports, therefore no reduction is necessary.

Table 35. Point source wasteload allocation for the Teton River subbasin.

Facility	NPDES Permit Number	Affected AU (ID17040204SK)	Present Design Flow (mgd)	Wasteload Allocation at Present Design Flow
				E. coli **(10^9 cfu/day/mgd)***
City of Driggs	ID-0020141	050_02 Woods Creek	0.6	2.57

Note: National Pollutant Discharge Elimination System (NPDES), million gallons per day (mgd), colony-forming units (cfu)
* 30-day geometric mean

5.3.5.1 Margin of Safety

For the AUs within the Teton River subbasin, the bacteria TMDLs have an explicit margin of safety set at 10% of Idaho's *E. coli* standard (Table 34). In addition, any conservative approaches used in the various calculations required by a TMDL are included as an implicit component of the margin of safety.

5.3.5.2 Seasonal Variation

For the Teton River subbasin AUs, the summer growing season is when concentrations of bacteria are the highest. This season is also when water flow is lowest. With lower water flow, bacteria concentrations increase due to a combination of agricultural diversion, cattle grazing, and limited water sources for wildlife. Seasonal variation, as it relates to development of this TMDL, is addressed by ensuring that loads are reduced during the critical period (when beneficial uses are impaired and loads are controllable). Thus, the effects of seasonal variation are built into the load allocations. However, the 126 organisms/100 mL allocation is expected to be met year-round.

5.3.5.3 Natural Background

Based on beneficial uses of primary or secondary contact recreation in the Teton River subbasin, a geometric mean of 126 organisms/100 mL is deemed protective of beneficial uses and meeting water quality standards. This determination is dependent on identifying changes in the source load and pathways that have led to exceedances of the standard. Natural sources are assumed to be a portion of the target WQS.

5.4 Construction Stormwater and TMDL Wasteload Allocations

Stormwater runoff is water from rain or snowmelt that does not immediately infiltrate into the ground and flows over or through natural or man-made storage or conveyance systems. When undeveloped areas are converted to land uses with impervious surfaces—such as buildings, parking lots, and roads—the natural hydrology of the land is altered and can result in increased surface runoff rates, volumes, and pollutant loads. Certain types of stormwater runoff are considered point source discharges for Clean Water Act purposes, including stormwater that is associated with municipal separate storm sewer systems (MS4s), industrial stormwater covered under the Multi-Sector General Permit (MSGP), and construction stormwater covered under the Construction General Permit (CGP).

Table 36 describes EPA-regulated dischargers based on DEQ’s GIS database layer and their potential effects on TMDL waters.

5.4.1 Municipal Separate Storm Sewer Systems

Polluted stormwater runoff is commonly transported through MS4s, from which it is often discharged untreated into local water bodies. An MS4, according to (40 CFR 122.26(b)(8)), is a conveyance or system of conveyances that meets the following criteria:

- Owned by a state, city, town, village, or other public entity that discharges to waters of the US
- Designed or used to collect or convey stormwater (including storm drains, pipes, ditches, etc.)
- Not a combined sewer
- Not part of a publicly owned treatment works (sewage treatment plant)

To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain an NPDES permit from EPA, implement a comprehensive municipal stormwater management program (SWMP), and use BMPs to control pollutants in stormwater discharges to the maximum extent practicable.

Table 36. Water dischargers in the Teton River subbasin.

ID #	Facility Name	NPDES Type	Affected Drainage	Comments
IDU000456	AG RIM LLC - TETON VALLEY SCENIC PARKWAY	Construction MSGP	Packsaddle Creek (Category 4a for Sediment)	BMP regulated and state certified. No effects anticipated.
ID0020141	DRIGGS CITY OF - DRIGGS WWTP	Individual Municipal Permit	Woods Creek (Category 5 for *E. Coli*)	Facility discharges to a tributary of Woods Creek, which is impaired for bacteria. See Table 35 for wasteload allocation.
IDR10B840	HUNTSMAN SPRINGS INC	Construction MSGP	Teton Creek (fully supporting)	BMP regulated and state certified. Not a TMDL water
IDR10B220	HUPPERT BROTHERS CONSTRUCTION INC	Construction MSGP	Fox Creek (4a – Sediment and Temperature; 4c)	BMP regulated and state certified. No effects anticipated.
IDU000076	JERRY DALLING FEEDLOT	CAFO	North Fork Teton River (4a – Sediment and Phosphorus; 4c)	BMP regulated and state certified. No effects anticipated.
IDR10AN75	MELEHES BROTHERS INC	Construction MSGP	Fox Creek (4a – Sediment and Temperature; 4c)	BMP regulated and state certified. No effects anticipated.
ID0023817	REXBURG WWTP	Individual Municipal Permit	South Fork Teton River (fully supporting)	BMP regulated and state certified. Not a TMDL water
IDU000219	SAGEWOOD LLC	Construction MSGP	Teton Creek (fully Supporting)	BMP regulated and state certified. Not a TMDL water
IDU000457	SHANE KAUFMAN CONSTRUCTION - TETON VALLEY SCENIC PARKWAY	Construction MSGP	Packsaddle Creek (4a for Sediment)	BMP regulated and state certified. No effects anticipated.
IDR10AN51	TETON VALLEY GOLF ASSOCIATES LP	Construction MSGP	Fox Creek (4a – Sediment and Temperature; 4c)	BMP regulated and state certified. No effects anticipated.
IDU000209	THE FELGER GROUP LLC	Construction MSGP	Teton Creek (fully Supporting)	BMP regulated and state certified. Not a TMDL water
IDU000458	WALTERS READY MIX INC	Industrial MSGP	South Fork Teton River (fully Supporting)	BMP regulated and state certified. Not a TMDL water
IDU000239	WELLS CONSTRUCTION LLC	Construction MSGP	Unassessed Teton River Tributaries	BMP regulated and state certified. Not a TMDL water

5.4.2 Industrial Stormwater Requirements

Stormwater runoff picks up industrial pollutants and typically discharges them into nearby water bodies directly or indirectly via storm sewer systems. When facility practices allow exposure of industrial materials to stormwater, runoff from industrial areas can contain toxic pollutants (e.g., heavy metals and organic chemicals) and other pollutants such as trash, debris, and oil and grease. This increased flow and pollutant load can impair water bodies, degrade biological habitats, pollute drinking water sources, and cause flooding and hydrologic changes, such as channel erosion, to the receiving water body.

Multi-Sector General Permit and Stormwater Pollution Prevention Plans

In Idaho, if an industrial facility discharges industrial stormwater into waters of the US, the facility must be permitted under EPA's most recent MSGP. To obtain an MSGP, the facility must prepare a stormwater pollution prevention plan (SWPPP) before submitting a notice of intent for permit coverage. The SWPPP must document the site description, design, and installation of control measures; describe monitoring procedures; and summarize potential pollutant sources. A copy of the SWPPP must be kept on site in a format that is accessible to workers and inspectors and be updated to reflect changes in site conditions, personnel, and stormwater infrastructure.

Industrial Facilities Discharging to Impaired Water Bodies

Any facility that discharges to an impaired water body must monitor all pollutants for which the water body is impaired and for which a standard analytical method exists (see 40 CFR Part 136).

Also, because different industrial activities have sector-specific types of material that may be exposed to stormwater, EPA grouped the different regulated industries into 29 sectors, based on their typical activities. Part 8 of EPA's MSGP details the stormwater management practices and monitoring that are required for the different industrial sectors. EPA issued its most recent MSGP in June 2015. DEQ anticipates including specific requirements for impaired waters as a condition of the 401 certification. The new MSGP details the specific monitoring requirements.

TMDL Industrial Stormwater Requirements

When a stream is on Idaho's §303(d) list and has a TMDL developed, DEQ may incorporate a wasteload allocation for industrial stormwater activities under the MSGP. However, most load analyses developed in the past have not identified sector-specific numeric wasteload allocations for industrial stormwater activities. Industrial stormwater activities are considered in compliance with provisions of the TMDL if operators obtain an MSGP under the NPDES program and implement the appropriate BMPs. Typically, operators must also follow specific requirements to be consistent with any local pollutant allocations. The next MSGP will have specific monitoring requirements that must be followed.

5.4.3 Construction Stormwater

The Clean Water Act requires operators of construction sites to obtain permit coverage to discharge stormwater to a water body or municipal storm sewer. In Idaho, EPA has issued a general permit for stormwater discharges from construction sites.

Construction General Permit and Stormwater Pollution Prevention Plans

If a construction project disturbs more than 1 acre of land (or is part of a larger common development that will disturb more than 1 acre), the operator is required to apply for a CGP from EPA after developing a site-specific SWPPP. The SWPPP must provide for the erosion, sediment, and pollution controls they intend to use; inspection of the controls periodically; and maintenance of BMPs throughout the life of the project. Operators are required to keep a current copy of their SWPPP on site or at an easily accessible location.

TMDL Construction Stormwater Requirements

When a stream is on Idaho's §303(d) list and has a TMDL developed, DEQ may incorporate a gross wasteload allocation for anticipated construction stormwater activities. Most loads developed in the past did not have a numeric wasteload allocation for construction stormwater activities. Construction stormwater activities are considered in compliance with provisions of the TMDL if operators obtain a CGP under the NPDES program and implement the appropriate BMPs. Typically, operators must also follow specific requirements to be consistent with any local pollutant allocations. The CGP has monitoring requirements that must be followed.

Postconstruction Stormwater Management

Many communities throughout Idaho are currently developing rules for postconstruction stormwater management. Sediment is usually the main pollutant of concern in construction site stormwater. DEQ's *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties* (DEQ 2005) should be used to select the proper suite of BMPs for the specific site, soils, climate, and project phasing in order to sufficiently meet the standards and requirements of the CGP to protect water quality. Where local ordinances have more stringent and site-specific standards, those are applicable.

5.5 Reasonable Assurance

Under §319 of the Clean Water Act, each state is required to develop and submit a nonpoint source management plan. Idaho's most recent *Nonpoint Source Management Plan* (DEQ 2015) was approved by EPA in March 2015. Among other things, the plan identifies programs to achieve implementation of nonpoint source BMPs, includes a schedule for program milestones, outlines key agencies and agency roles, is certified by the state attorney general to ensure that adequate authorities exist to implement the plan, and identifies available funding sources.

Idaho's Nonpoint Source Management Program describes many of the voluntary and regulatory approaches the state will take to abate nonpoint pollution sources. One of the prominent programs described in the plan is the provision for public involvement, such as the formation of basin advisory groups and watershed advisory groups (WAGs). The Teton WAG is the designated WAG for the Teton River subbasin.

The Idaho water quality standards refer to existing authorities to control nonpoint pollution sources in Idaho. Some of these authorities and responsible agencies are listed in Table 37.

Table 37. State of Idaho's regulatory authority for nonpoint pollution sources.

Authority	Water Quality Standards Citation	Responsible Agency
Rules Pertaining to the Idaho Forest Practices Act (IDAPA 20.02.01)	58.01.02.350.03.a	Idaho Department of Lands
Solid Waste Management Rules and Standards (IDAPA 58.01.06)	58.01.02.350.03.b	Idaho Department of Environmental Quality
Individual/Subsurface Sewage Disposal Rules (IDAPA 58.01.03)	58.01.02.350.03.c	Idaho Department of Environmental Quality
Stream Channel Alteration Rules (IDAPA 37.03.07)	58.01.02.350.03.d	Idaho Department of Water Resources
Rathdrum Prairie Sewage Disposal Regulations (Panhandle District Health Department)	58.01.02.350.03.e	Idaho Department of Environmental Quality, Panhandle District Health Department
Rules Governing Exploration, Surface Mining and Closure of Cyanidation Facilities (IDAPA 20.03.02)	58.01.02.350.03.f	Idaho Department of Lands
Dredge and Placer Mining Operations in Idaho (IDAPA 20.03.01)	58.01.02.350.03.g	Idaho Department of Lands
Rules Governing Dairy Waste (IDAPA 02.04.14)	58.01.02.350.03.h	Idaho State Department of Agriculture

The State of Idaho uses a voluntary approach to address agricultural nonpoint sources. However, regulatory authority can be found in the water quality standards (IDAPA 58.01.02.350.01–03). IDAPA 58.01.02.055.07 refers to the *Idaho Agricultural Pollution Abatement Plan* (Ag Plan) (SCC and DEQ 2003), which provides direction to the agricultural community regarding approved BMPs. A portion of the Ag Plan outlines responsible agencies or elected groups (soil conservation districts) that will take the lead if nonpoint source pollution problems need to be addressed. For agricultural activity, the Ag Plan assigns the local soil conservation districts to assist the landowner/operator with developing and implementing BMPs to abate nonpoint source pollution associated with the land use. If a voluntary approach does not succeed in abating the pollutant problem, the state may seek injunctive relief for those situations determined to be an imminent and substantial danger to public health or the environment (IDAPA 58.01.02.350.02.a).

The Idaho water quality standards and wastewater treatment requirements specify that if water quality monitoring indicates that water quality standards are not being met, even with the use of BMPs or knowledgeable and reasonable practices, the state may request that the designated agency evaluate and/or modify the BMPs to protect beneficial uses. If necessary, the state may seek injunctive or other judicial relief against the operator of a nonpoint source activity in accordance with the DEQ director's authority provided in Idaho Code §39-108 (IDAPA 58.01.02.350). The water quality standards list designated agencies responsible for reviewing and revising nonpoint source BMPs: the Idaho Department of Lands for timber harvest activities, oil and gas exploration and development, and mining activities; the Idaho Soil and Water Conservation Commission for grazing and agricultural activities, the Idaho Transportation

Department for public road construction, the Idaho State Department of Agriculture for aquaculture, and DEQ for all other activities (IDAPA 58.01.02.010.24).

5.6 Implementation Strategies

Implementation strategies for TMDLs produced using PNV-based shade and solar loads should incorporate the load analysis tables presented in this TMDL (Tables 17–26). These tables need to be updated, first to field verify the remaining existing shade levels and second to monitor progress toward achieving reductions and TMDL goals. Using the Solar Pathfinder to measure existing shade levels in the field is important to achieving both objectives. It is likely that further field verification will find discrepancies with reported existing shade levels in the load analysis tables. Due to the inexact nature of the aerial photo interpretation technique, these tables should not be viewed as complete until verified. Implementation strategies should include Solar Pathfinder monitoring to simultaneously field verify the TMDL and mark progress toward achieving desired load reductions.

There may be a variety of reasons that individual stream segments do not meet shade targets, including natural phenomena (e.g., beaver ponds, springs, wet meadows, and past natural disturbances) and/or historic land use activities (e.g., logging, grazing, and mining). It is important that existing shade for each stream segment be field verified to determine if shade differences are real and result from activities that are controllable. Information within this TMDL (maps and load analysis tables) should be used to guide and prioritize implementation investigations. The information in this TMDL may need further adjustment to reflect new information and conditions in the future.

Similar and complimentary requirements to the temperature implementation are necessary for implementing streambank stability and bacteria reductions. Implementation of the sediment TMDL relies on multiple factors, includes stabilizing streambanks, improving agricultural practices, and removing fines in the substrate. Improvements in riparian communities will both help stabilize the streambank and limit bacteria pathways into the stream channel. This presumes that the Teton River and tributaries will receive changes in land management, which may be coupled with additional exclosure fencing, that are proven effective at improving riparian woody-plant density.

Implementation of the bacteria TMDL is already in effect with the current management of grazing allotments limiting cattle residence in riparian habitat. Grazing management will continue to improve the condition of the North Fork Moody Creek watershed, but regular monitoring will be required to determine if current management is sufficient to meet water quality standards.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or significant progress is not being made toward achieving the goals. Reasonable assurance (addressed in section 5.5) for the TMDL to meet water quality standards is based on the implementation strategy.

DEQ and the WAG will continue to re-evaluate TMDLs on a 5-year cycle. During the 5-year review, implementation actions completed, in progress, and planned will be reviewed, and pollutant load allocations will be reassessed accordingly.

5.6.1 Time Frame

Implementing the temperature TMDL relies on riparian area management practices that will provide a mature canopy cover to shade the stream and prevent excess solar loading. Because implementation is dependent on mature riparian communities to substantially improve stream temperatures, DEQ believes 10–20 years may be a reasonable amount time for achieving water quality standards. Shade targets will not be achieved all at once. Given their smaller bankfull widths, smaller streams may reach targets sooner than larger streams.

DEQ believes that a time frame of 5–10 years is required to begin the process of streambank stabilization and initial identification of diminished volumes of fine sediment. Given their smaller bankfull widths, smaller streams may reach targets sooner than larger streams. It is estimated that without new sediment inputs, the removal of the fines on the substrate and re-development of the thalweg will take approximately 5 years.

E. coli impairments are extremely variable by season and mitigation options. For example, exclosure fencing can cause nearly instant improvements, as was the case in Warm Creek (Trail Creek subwatershed). If the primary source for the *E. coli* is not from domesticated animal sources, the time frame is more difficult to reconcile and adjust via restoration activities.

5.6.2 Responsible Parties

DEQ's Water Quality Division is responsible for ensuring that the Idaho's surface waters meet state water quality standards and support their beneficial uses. This involves monitoring, assessment, and collaborating with other Designated Management Agencies and landowners of key riparian habitats. These lead agencies include the Idaho State Department of Agriculture, Idaho Department of Lands, Idaho Transportation Department, Idaho Soil and Water Conservation Commission, NRCS, BLM, and USFS, which are working cooperatively to implement these TMDLs by increasing streambank stability and vegetative cover and improving grazing practices (DEQ 2015). Practices dictated by the latest scientific knowledge and technology will lead to a reduction in solar loading that may currently be impairing beneficial uses such as salmonid spawning. Federal, state, and local funding sources can provide the means to implement targeted BMPs.

5.6.3 Implementation Monitoring Strategy

Effective shade monitoring can take place on any segment throughout the 9 temperature-impaired AUs and be compared to existing shade estimates. Those areas with the largest disparity between existing and target shade should be monitored with Solar Pathfinders to verify existing shade levels and determine progress toward meeting shade targets. Since many existing shade estimates have not been field verified, they may require adjustment during the implementation process. Stream segment length for each estimate of existing shade varies depending on the land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade toward target levels. Ten equally spaced Solar Pathfinder measurements averaged together within that segment should suffice to determine new shade levels in the future. Monitoring locations for temperature can occur on any segment included in Tables 17–26 and should be re-examined for the next review.

Use of the SEI is recommended to maintain consistency and comparability in the sediment results.

Bacteria monitoring should remain consistent and a 5-sample geometric mean should be calculated.

5.6.4 Pollutant Trading

Pollutant trading (also known as water quality trading) is a contractual agreement to exchange pollution reductions between two parties. Pollutant trading is a business-like way of helping to solve water quality problems by focusing on cost-effective, local solutions to problems caused by pollutant discharges to surface waters. Pollutant trading is one of the tools available to meet reductions called for in a TMDL where point and nonpoint sources both exist in a watershed.

The appeal of trading emerges when pollutant sources face substantially different pollutant reduction costs. Typically, a party facing relatively high pollutant reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction.

Pollutant trading is voluntary. Parties trade only if both are better off because of the trade, and trading allows parties to decide how to best reduce pollutant loadings within the limits of certain requirements.

Pollutant trading is recognized in Idaho's water quality standards at IDAPA 58.01.02.055.06. DEQ allows for pollutant trading as a means to meet TMDLs, thus restoring water quality limited water bodies to compliance with water quality standards. DEQ's *Water Quality Pollutant Trading Guidance* sets forth the procedures to be followed for pollutant trading (DEQ 2010b).

5.6.4.1 Trading Components

The major components of pollutant trading are trading parties (buyers and sellers) and credits (the commodity being bought and sold). Ratios are used to ensure environmental equivalency of trades on water bodies covered by a TMDL. All trading activity must be recorded in the trading database by DEQ or its designated party.

Both point and nonpoint sources may create marketable credits, which are a reduction of a pollutant beyond a level set by a TMDL:

- Point sources create credits by reducing pollutant discharges below NPDES effluent limits set initially by the wasteload allocation.
- Nonpoint sources create credits by implementing approved BMPs that reduce the amount of pollutant runoff. Nonpoint sources must follow specific design, maintenance, and monitoring requirements for that BMP; apply discounts to credits generated, if required; and provide a water quality contribution to ensure a net environmental benefit. The water quality contribution also ensures the reduction (the marketable credit) is surplus to the reductions the TMDL assumes the nonpoint source is achieving to meet the water quality goals of the TMDL.

5.6.4.2 Watershed-Specific Environmental Protection

Trades must be implemented so that the overall water quality of the water bodies covered by the TMDL are protected. To do this, hydrologically based ratios are developed to ensure trades between sources distributed throughout TMDL water bodies result in environmentally equivalent or better outcomes at the point of environmental concern. Moreover, localized adverse impacts to water quality are not allowed.

5.6.4.3 Trading Framework

For pollutant trading to be authorized, it must be specifically mentioned within a TMDL document. After adoption of an EPA-approved TMDL, DEQ, in concert with the WAG, must develop a pollutant trading framework document. The framework would mesh with the implementation plan for the watershed that is the subject of the TMDL. The elements of a trading document are described in DEQ's pollutant trading guidance (DEQ 2010b).

6 Conclusions

Significant changes in land use management and water availability have begun to improve the water quality in the Teton River subbasin (HUC 17040204); however, many areas are still impaired or have not yet recovered from earlier land-use activities. Continued implementation of BMPs and water right alterations will be required, along with monitoring to confirm changes in years to come. A summary of assessment outcomes, including recommended changes to listing status in the next Integrated Report, is presented in Table 38.

Table 38. Teton River subbasin summary of assessment outcomes.

Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to Next Integrated Report	Justification
ID17040204SK006_02, South Fork Moody Creek – source to mouth	Sedimentation/ siltation	Yes	Place in Category 4a for sediment	Sediment TMDL completed based on streambank stability
ID17040204SK007_02, North Fork Moody Creek – source to mouth	Fecal coliform	Yes	Place in Category 4a for *E. coli*, delist for fecal coliform	*E. coli* TMDL based on geometric mean
ID17040204SK011_02, Warm Creek – source to mouth (Canyon Creek watershed)	Combined biota/habitat bioassessments; fecal coliform	No	Delist combined biota/habitat bioassessments; delist for fecal coliform; move to Category 2	BURP monitoring occurred in a wetland; *E. coli* measured below threshold—listed based on data from Warm Creek (Trail Creek watershed)
ID17040204SK017_04, Teton River – Cache Bridge to Highway 33 Bridge	No 2012 impaired listing	Yes	Place in Category 4a for temperature, retain in 4a for sediment	Potential natural vegetation (PNV) temperature TMDL, excess solar load from a lack of existing shade; sediment loads updated
ID17040204SK020_04, Teton River – Teton Creek to Cache Bridge		Yes		
ID17040204SK026_02, Teton River – Tributaries between Trail Creek to Teton Creek	No 2012 impaired listing	Yes	Retain in Category 4a for temperature, retain in 4a for sediment	Potential natural vegetation (PNV) temperature TMDL, excess solar load from a lack of existing shade
ID17040204SK026_04, Teton River – Trail Creek to Teton Creek	No 2012 impaired listing	Yes	Place in Category 4a for temperature, retain in 4a for sediment	Potential natural vegetation (PNV) temperature TMDL, excess solar load from a lack of existing shade; sediment loads updated
ID17040204SK028_03, Teton River – Warm and Drake Creeks confluence to Trail Creek	No 2012 impaired listing	Yes	Place in Category 4a for temperature and sediment	PNV temperature TMDL, excess solar load from a lack of existing shade; sediment TMDL completed based on streambank stability
ID17040204SK034_02, Warm Creek – source to mouth (Trail Creek watershed)	Combined biota/habitat bioassessments; fecal coliform	No	Delist combined biota/habitat bioassessments; delist for fecal coliform; move to Category 4c for low flow alterations	*E. coli* geometric mean below threshold; land use changes include increased fencing; low flow alterations are sole cause for impairment
ID17040204SK035_03, Trail Creek – diversion to mouth	No 2012 impaired listing	Yes	Place in Category 4a for sediment; place in Category 4c for low flow alterations	Sediment TMDL completed based on streambank stability, stream channel erodes when water is present; low flow alterations are an additional impairment cause
ID17040204SK041_02, Fox Creek	No 2012 impaired listing	Yes	Retain in Category 4a for temperature	Temperature TMDL updated to PNV, excess solar load from a lack of existing shade
ID17040204SK042_02, Fox Creek	No 2012 impaired listing	Yes	Move to Category 2 for temperature TMDL compliance	Temperature TMDL updated to PNV, no excess solar load
ID17040204SK046_02, Dick Creek spring complex	Combined biota/habitat bioassessments	No	Delist combined biota/habitat bioassessments; place in 4c for low flow alterations	Low flow alterations are sole cause for impairment
ID17040204SK049_02, Driggs Springs spring creek complex – located between Teton Creek and Woods Creek	*Escherichia coli*	Yes	Place in Category 4a for *E. coli*. Delist fecal coliform.	*E. coli* TMDL based on geometric mean

Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to Next Integrated Report	Justification
ID17040204SK050_02, Woods Creek – source to mouth, including spring creek tributaries		Yes		
ID17040204SK054_03, Spring Creek – North Leigh Creek to Mouth	No 2012 impaired listing	Yes	Retain in Category 4a for temperature	Temperature TMDL updated to PNV, excess solar load from a lack of existing shade
ID17040204SK056_02, Spring Creek – source to North Leigh Creek		Yes		
ID17040204SK056_03, Spring Creek – source to North Leigh Creek		Yes		

Certain AUs currently listed in the 2012 Integrated Report for various causes have been determined to be impaired solely due to flow alteration (and thus do not require a TMDL). This dewatering adequately explains many of the impairments, except where sediment TMDLs exist, as the channel bed and banks are prone to erosion if/when water is present. Trail Creek (ID17040204SK035_03) has irrigation withdrawals that often remove all the water from the channel but is impaired by sediment and is also a source to receiving waters. Both Warm Creek – source to mouth (Trail Creek watershed) (ID17040204SK034_02) and Dick Creek spring complex (ID17040204SK046_02) are impacted by water removal.

Effective shade targets were established for 10 AUs in the Teton Valley based on the concept of maximum shading under PNV resulting in natural background temperature levels. Shade targets were derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation and partially field verified with Solar Pathfinder data. Target and existing shade levels were compared to determine the amount of shade needed to bring water bodies into compliance with temperature criteria in Idaho's water quality standards (IDAPA 58.01.02).

All streams except Fox Creek AU ID17040204SK042_02 lack shade, but to varying degrees. The 2nd-order tributaries to the Teton River tend to have the highest necessary load reductions. The Teton River itself has sporadic willow communities to provide shade in places; however, the river is wide in general and would have low shade potential. Upper portions of the Fox Creek and Spring Creek watersheds are in the aspen/cottonwood zone and can lack considerable shade in places where such trees have been removed for pasture or other reasons. Target shade levels for individual stream segments should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts.

Sediment was found to be impairing beneficial uses in 1 listed AU and 2 unlisted AUs; allocations for sediment load reductions are provided in this document. Additionally, 3 AUs received updated TMDLs. Load reductions are necessary to achieve less than 28% fines in the streambed. The TMDL is based on reaching an 80% streambank stability, as streambanks have been identified as the most likely source of sediment. South Fork Moody Creek has an allocated load reduction; however, some natural restabilization has occurred in the areas managed by the

USFS. Idaho Department of Lands managed lands have had recent logging in the State Creek portion, and there are limited BMPs to manage sediment production leading to siltation in State Creek. The main stem Teton River in the valley section is impaired by sediment both outside and inside the channel. The 2003 TMDL details the sediment loads from tributaries and hillsides and developed TMDLs. This TMDL updates the loads that are readily mobilized within the channel for 3 AUs.

E. coli was determined to be impairing water quality in 3 AUs; bacteria TMDLs are provided for restoring beneficial uses to these AUs. Two of these locations are believed to be impaired primarily by avian sources in a peat bog complex: Woods Creek (ID17040204SK050_02) and Driggs Springs complex (ID17040204SK049_02). The third AU, North Fork Moody Creek (ID17040204SK007_02), is believed to require improved grazing practices to limit *E. coli*. Due to continued and historic exceedances of the secondary contact recreation *E. coli* standard, bacteria monitoring should continue at designated locations in North Fork Moody Creek. Table 39 provides a list of recommended future monitoring for AUs within the subbasin.

Two NPDES permits are located in the area of concern; neither are deemed to have detrimental impacts on the receiving waters and no action is required. There were no Municipal, Stormwater, or Multi-Sector General Permit wasteload allocations developed as no MS4s or MSGPs exist within the subbasin. Permitted CGPs are considered in compliance with the intent of the TMDL so long as they follow their permit.

Table 39. Recommended future monitoring.

Assessment Unit	Listed Pollutant(s)/ Pollution	Status	Recommended Action
ID17040204SK006_02, South Fork Moody Creek – source to mouth	Sediment	Lack of BMPs in forest harvest leading to excessive sediment loads and siltation within stream channel	Regular observations to determine if loads are increasing or diminishing. Additional BURP and SEI monitoring in State Creek in 3-5 years.
ID17040204SK007_02, North Fork Moody Creek	Fecal coliform	Grazing practices heave lead to historic and continued exceedances of bacteria standards	Regular *E. coli* monitoring during grazing season should be completed annually to evaluate any changes in bacteria levels
ID17040204SK017_04, Cache Bridge to Highway 33 Bridge	Sediment	Current TMDL for sediment/siltation	BURP and SEI monitoring to gauge land use changes on water quality metrics
ID17040204SK017_04, ID17040204SK020_04, ID17040204SK026_04, ID17040204SK028_03,	Sediment, Temperature	2012 Monitoring to determine if nutrient concentrations were impairing beneficial uses or exceeding narrative standard	Regular monitoring and observation is required to examine for nutrient composition shifts leading to nuisance growth
ID17040204SK026_04, Tributaries between Trail Creek to Teton Creek	Sediment, Temperature	Updated TMDL for temperature, but current sediment TMDL still needs to be evaluated	Perform SEI monitoring to determine current sediment pollutant status

Monitoring for nutrients in 2012 found that the concentrations of nutrients (nitrate and total phosphorus) were greater than recommendations published in the literature. However, there were no identifiable impairments to beneficial uses caused by those nutrients. The sediment inputs were determined to be the largest identifiable source and pathway for nutrients into the channel;

therefore, mitigating actions to limit sediment and erosion as deemed necessary by the TMDLs should have secondary benefits of decreasing nutrient inputs, in particular, total phosphorus. Streambank stabilization and development of shading vegetation will also improve removal of nutrients (e.g., surface water–ground water interactions) in meeting the goals established for the temperature TMDL.

This document was prepared with input from the public, as described in Appendix J. The development of this Teton River subbasin TMDL addendum includes a public comment period. DEQ responded to the comments by amending the document and clarifying issues as necessary. Details of public participation, distribution lists, and comments are included in Appendix J and Appendix K.

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GIS Coverages

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Appendix A. State and Site-Specific Water Quality Standards and Criteria

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning and egg incubation period, which varies by species. For spring-spawning salmonids, the default spawning and incubation period recognized by the Idaho Department of Environmental Quality (DEQ) is generally March 15 to July 15 (Grafe et al. 2002). Fall spawning can occur as early as September 1 and continue with incubation into the following spring up to June 1. As per IDAPA 58.01.02.250.02.f.ii., the following water quality criteria need to be met during that time period:

- 13 °C as a daily maximum water temperature
- 9 °C as a daily average water temperature

For the purposes of a temperature TMDL, the highest recorded water temperature in a recorded data set (excluding any high water temperatures that may occur on days when air temperatures exceed the 90th percentile of the highest annual maximum weekly maximum air temperatures) is compared to the daily maximum criterion of 13 °C. The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

Natural Background Provisions

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during certain time periods. If potential natural vegetation targets are achieved yet stream temperatures are warmer than these criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human-induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply:

> When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, there shall be no lowering of water quality from natural background conditions. Provided, however, that temperature may be increased above natural background conditions when allowed under Section 401. (IDAPA 58.01.02.200.09)

Section 401 relates to point source wastewater treatment requirements. In this case, if temperature criteria for any aquatic life use are exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3 °C (IDAPA 58.01.02.401.01.c).

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Appendix B. Assessment Unit Notes and Observations

Assessment Unit Requiring TMDL Development

South Fork Moody Creek – Source to Mouth

ID17040204SK006_02

During the development of the 2003 TMDL, this stream was identified as having excessive sediment but no TMDL was created. The original TMDL document indicated that recreation and cattle were suspected to be the primary drivers for sediment in the channel.

Background (provided by Lee Mabey of the USFS)

In 2003, a decision was signed after completion of the Moody South Fork, Burns Environmental Assessment. This decision split the Moody South Fork Allotment into two separate allotments: the Moody Allotment and the Lookout Mountain Allotment. Implementation of the decision led to the creation of a five-pasture rest rotation system on the Moody Allotment (Figure B1), an exclosure on Fish Creek (Figures B2–5), and a riparian pasture at the Fish Creek Moody confluence. These changes took several miles of fence to implement. This fencing was not completed until 2006, and the new rotation system began in 2007.

A capacity study was conducted over the next five years to see that the allotment could be managed within the grazing standards using the new rotation. Previously, the entire allotment had been used every year. With the new system, approximately 20% of the allotment is rested annually. Rest units often must be crossed while moving cattle to the next unit, so they do receive some use most years, but the use is much lighter than the grazing standards. The capacity study showed that the allotment could be managed with the permitted cattle using the rest rotation system. The system also allowed the permittee greater control of the cattle, which made it easier to meet standards throughout the allotment. Prior to implementation of the new system, there were locations that received nearly season-long use. Now the permittee can move cattle to the next unit sooner, allowing these heavily used areas to rest and to meet grazing standards for the allotment. This rotational grazing system has helped the permittee better manage cattle use throughout the entire Moody Allotment, which includes most of North and South Moody Creeks and their tributaries on USFS land, including Fish Creek, Sheep Creek, Browning Creek, and Garner Creek.

The relocation of the Fish Creek trail was also part of the allotment decision. In 2004, approximately 1.5 miles of trail that were in or directly adjacent to the riparian zone in Fish Creek were moved up onto the side hill. The trail was designed with proper drainage to minimize erosion. Creek crossings were hardened and some culverts were installed in boggy locations (Figures B6–7). The hardened crossings are still generating some stream issues, and the District is currently trying to secure funding to bridge these crossings.

The decision also closed the two-track road on the ridge divide between South Moody and Fish Creeks and the two-track road extending from the end of North Moody, Forest Road #258 down into South Moody Creek.

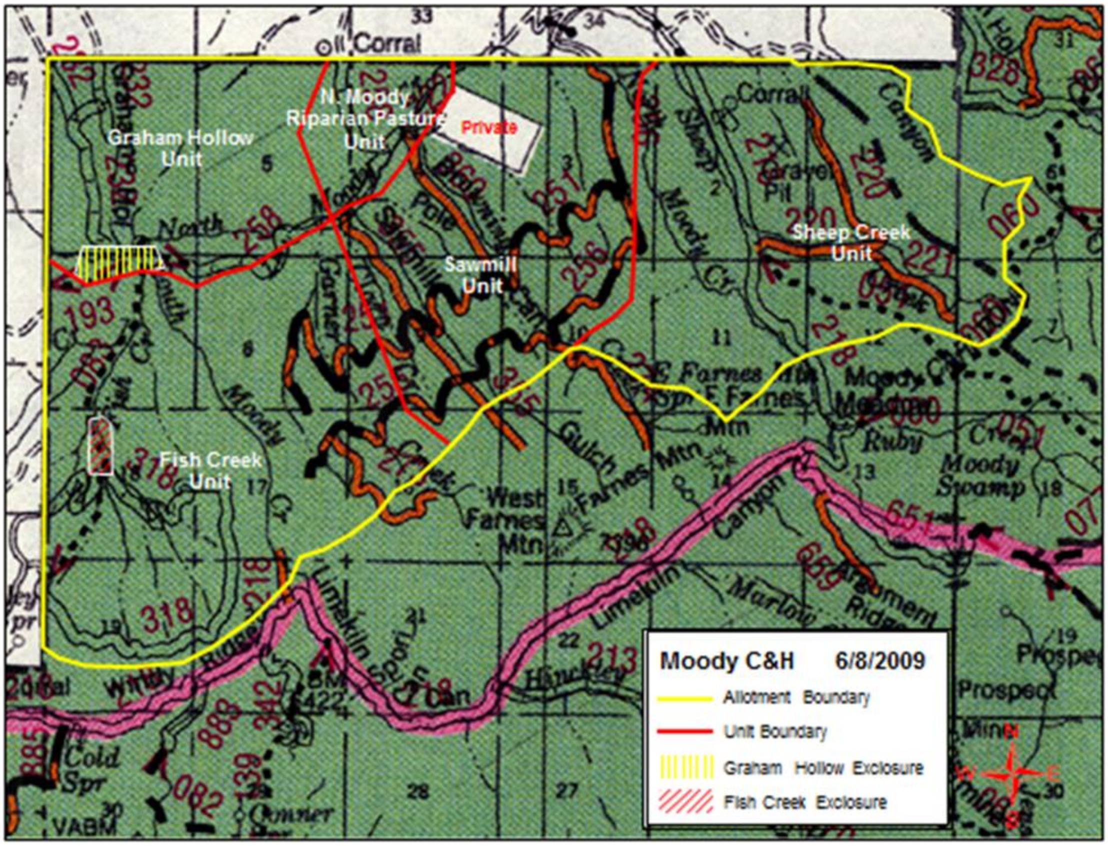

Figure B1. Moody Allotment showing 5 pastures within the allotment boundary.

Figure B2. Fish Creek exclosure during construction. Note the heaviliy used trail and vertical banks. The vertical banks were not originally treated.

Figure B3. Fish Creek exclosure post-construction.

Figure B4. DEQ photo showing vertical banks that were not protected with growing grasses.

Figure B5. A 2015 project resloped vertical banks and replanted sod mats next to the stream. Willows were planted, the area was seeded, and an undersized culvert was replaced.

The travel plan from 1997 and subsequent revisions in 2010 have removed all cross country motorized travel and designated trails as open to motor vehicles less than 50" wide, single track motorized, or non-motorized. The District continues to implement this travel plan. In 2010 and 2011, the District used machinery and jack fencing to close several miles of user-created trails, old logging roads, and skid trails, which are not part of the designated trail system. These were being used by motorized recreationists.

Figure B6. Crossing on Fish Creek (before).

Figure B7. Crossing on Fish Creek (after)

DEQ Notes

DEQ employees visited South Fork Moody Creek on two dates in 2013 (June 24 and August 21) to compare different seasonal conditions. Management and improvement actions by the USFS, as detailed above, are leading to meeting sediment goals and instream condition. Fencing and hardened stream crossings have been added within the AU and specifically in the South Fork Moody Creek channel. There were indications of ATV and mountain bike use in the area. In those locations, the channel condition is improving and expected to meet sediment goals by the next 5-year review cycle. In the upper Fish Creek area, exclosure fencing has been installed and gullies appear to be stabilizing but had not reached an equilibrium state during the preparation of this TMDL. It is not expected that this upper reach (which was dry in August 2013) will return to its previous condition; there are signs that a new stable state and channel is being formed at the bottom of the gullies.

However, forest harvest has occurred in the upper reaches of State Creek with slash piles, roadways, and loading zones located in the upper sections of the stream (which was dry in August 2013 and July 2014). This use removed vegetation, compacted the soils, and created an area where sediment was readily mobilized into the stream. There were no identified BMPs to limit soil transport. Cattle were also seen grazing in these susceptible areas after logging had occurred. As a result, State Creek has silt build-up in channel and pools are becoming/are full of sediment, all of which will be transported into South Fork Moody Creek. Additional input into State Creek will continue until the soils compacted in the upper reaches have returned to near preharvest condition. Use of limited BMPs would have mitigated this sediment build up. Compacted soils under logging roads were not effectively decommissioned; it appears that downed trees blocked access but did little to mitigate erosion.

State Creek contributes significant sediment loads to South Fork Moody Creek, thereby negating the improvements on USFS lands; therefore, a sediment TMDL is being developed. Re-examination and additional BURP monitoring of this AU to examine recovery is recommended prior to the next subbasin assessment.

Figures B8–B17 show current conditions in this AU.

Figure B8. South Fork Moody Creek, showing bank stabilization and fencing.

Figure B9. South Fork Moody Creek stream crossing with ATV hardened crossing.

Figure B10. Upstream view of South Fork Moody Creek with signs of bank instability on the left bank.

Figure B11. Upper Fish Creek and signs of returning stability within the gully; channel was dry at time of photo.

Figure B12. State Creek sediment accumulation in-channel.

Figure B13. State Creek sediment accumulation in-channel.

2013 2014

Figure B14. State Creek sediment accumulation in-channel below logging (less than 300 feet apart).

Figure B15. Slash pile and erosion in logging road compacted area in the upper State Creek drainage; ephemeral wash without BMPs.

Figure B16. Fine particle size sediment build-up in logged area of perennial portion of State Creek.

Figure B17. Slash pile and loading zone in upper portion State Creek, just above perennial portion.

Assessment Unit Requiring Moving to Category 2

Warm Creek (Canyon Creek Watershed) – Source to Mouth

ID17040204SK011_02

Warm Creek (Canyon Creek watershed) was listed based solely on BURP scores from 1997. The area that was monitored is currently a wetland which was altered both by the roadway and sediment washed down from above at an unknown time. The BURP monitoring in 1997 was partially/totally within the wetland area and therefore did not meet the accepted BURP protocols for identifying stream beneficial uses.

Warm Creek (ID17040204SK011_02) was visited on June 24, 2013. DEQ personnel hiked into the stream significantly above the wetland at the road crossing, through previously harvested areas, and found the stream to be stable and with limited erodible material in the channel. Portions of this watershed were clearcut and roads crisscrossed the landscape. Many of these roads have been closed and removed from service, and there is regrowth in the clearcuts. The combination of road closures and changes in timber harvest activity has limited the input of potential sediment from those sources. The other potential current source appears to be the colluvium falling into the channel from the eroding cliffs and talus slopes along the channel. There were indications of limited inputs of fine particles. Typically the channel bed was composed of gravel to cobble-sized particles of limited concern to the channel substrate. An SEI was performed and determined a slight erosion risk for streambank erosion that is below the carrying capacity.

Based on the culvert at the road crossing (see pictures), it is not expected that fish could naturally return to this stream. It would not be safe to hike into the stream while carrying electrofishing equipment as there were steep hillslopes, no trails, and significant numbers of downed trees that required climbing under and over. The north-facing slopes were thick with pine trees, while the south-facing slopes were composed mostly of bunch grasses. The riparian area consisted of willows and alders. Besides being shallow and confined by the canyon walls, the stream did not have any obvious impairment. There may have been sediment issues from logging in the past; however, the current indications of this as an impairment are minimal.

The *E. coli* monitoring in Warm Creek (Canyon Creek watershed) measured 40 organisms/100 mL in 1999 at the BURP site (1997SIDFL018), and this number of colonies does not trigger a need for a 5-sample geometric mean. When assessed, the datasheets for Warm Creek (Trail Creek watershed) were erroneously used to list the stream for fecal coliform. ADB contains the listing justifications, with each Warm Creek (there are two in the subbasin) noted as having an *E. coli* geometric mean of 541 organisms/100 mL. The datasheets with an *E. coli* of 541 organisms/100 mL geometric mean are labeled for the BURP site number 1997SIDFL063, which is located in the Trail Creek watershed, and a fecal coliform measure of 435 organisms/100 mL. However, Warm Creek (Canyon Creek watershed) was re-examined for *E. coli* in 2011, which confirmed the limited number of *E. coli* colonies; the geometric mean was 44 organisms/100 mL. The initial fecal coliform (now *E. coli*) assessment listing was based on an error and this AU should be removed from Category 5 for fecal coliform.

To clarify apparent inconsistencies in the datasheets, the BURP site number style was updated from using the EIRO (Eastern Idaho Regional Office) to the SIDF style and the paper forms were not always manually updated.

The BURP monitoring wetland location sampled during 1997 was not representative of the stream, and the data do not support a Category 5 impaired listing in the Integrated Report for aquatic life. Assessment of the BURP data did not recognize the habitat as being in a wetland and therefore the assessment conclusion of impaired should be re-evaluated in this situation. This AU should be moved to Category 2 until DEQ can send out a BURP crew capable of hiking into the stream, over the deadfall, etc. to reach a location that is representative of the AU. Monitoring for fish populations is not recommended as the culvert structure is a barrier to migration and movement.

Figure B18. Decommissioned forest road.

Figure B19. Streamchannel below decommissioned forest road.

Figure B20. Ponded channel above road, site of BURP 1997SIDFL018 with failing habitat scores.

Figure B21. Culvert on Warm Creek just upstream of confluence with Canyon Creek.

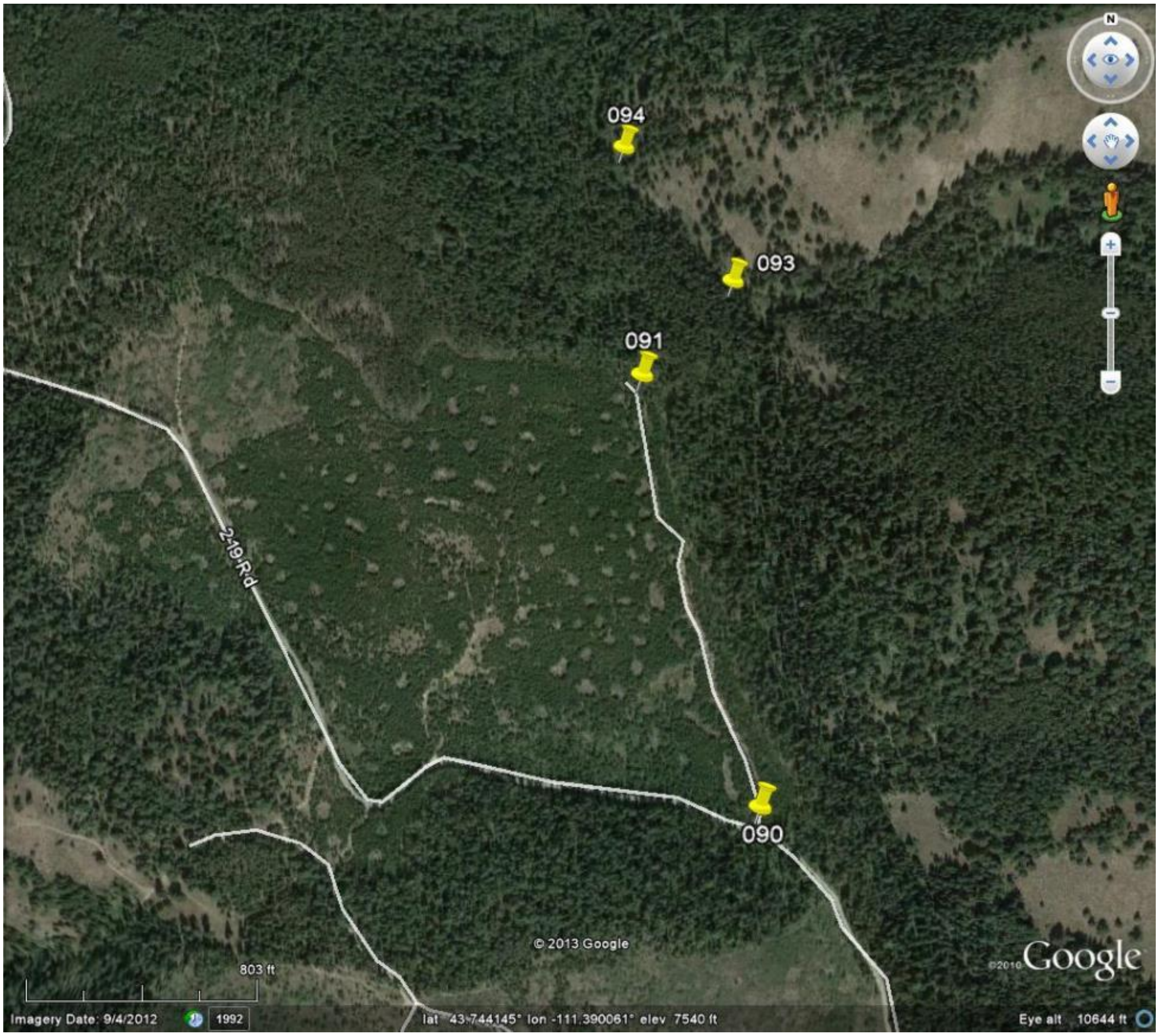

Figure B22. At point 090 is the decommissioned forest road leading into the recovering forest harvest. Potions of the visited stream segment are indicated by points 093 and 094.

Assessment Units Requiring Category 4c Designation

In addition to the AUs listed below, site visits occurred at multiple AUs throughout the subbasin that currently do not require TMDLs or have any indications that other actions or assessments would be required during the development of this TMDL. These locations include (but are not limited to) Bitch Creek, Packsaddle Creek, Horseshoe Creek, North and South Fork Teton River, Teton River above and below the failed dam location, Canyon Creek, Moose Creek, Mike Harris Creek, Dick Creek, Badger Creek, Spring Creek, and Fox Creek.

Warm Creek (Trail Creek Watershed) – Source to Mouth

ID17040204SK034_02

Warm Creek (Trail Creek watershed) was listed based only on a BURP score from 1997 and bacteria monitoring in 1999. The stream was later assessed as impaired for combined biota/habitat bioassessments and fecal coliform. The 1997 BURP monitoring occurred in an agricultural field in what should have been considered a canal. The channel had been straightened and the surrounding area is an active agricultural field. The channel itself is essentially in a canal that has not been maintained in locations and in places appears to have "gone wild" but is still constrained by surrounding historic and current land-use. The ecological function of that channel is limited by historic alterations and current land management practices that limit the development of the expected sinuosity of a channel in that soil type and gradient.

When assessed, Warm Creek (Trail Creek watershed) was found to be impaired for fecal coliform (current methods are for *E. coli*) and was measured for both. The stream had *E. coli* measured at 541 organisms/100 mL as a geometric mean in 1999. However, Warm Creek (Trail Creek watershed) was re-examined for *E. coli* in 2011 and found to have a geometric mean of 51 organisms/100 mL. This 2011 measurement falls within the Idaho water quality standards and justifies removing the impairment for the Warm Creek (Trail Creek watershed) assessment unit. This stream had been heavily altered by agriculture in 1997 during the BURP monitoring. By 2011, the percentage of urbanization had dramatically increased diminishing inputs, and the increasing buffer zones around the stream/canal reaches effectively limited potential impacts from agriculture. Note the exclosure fencing along the modified stream reach in the photos below.

The SEI confirmed there were no sediment impairments in channel, nor was it a significant source of sediment to receiving waters. The only location that may have been a source was up Pole Canyon, where there is fairly heavy recreational use. However, the ATV/motorcycle route and crossing was hardened and shifted away from the channel. Tire tracks in the Pole Creek channel indicated that some users do not always comply with management plans. Additionally, the trail and stream have under gone improvements, moving the trail away from the stream and onto the hillside.

Figure B23. ATV trail.

There are numerous agricultural withdrawals from this stream and multiple headgates, but it does not appear to be completely dewatered during normal water years. Therefore, DEQ expects some biologic function in this channel; however, meeting full BURP biologic support for such a modified system is unlikely. DEQ recommends altering the Integrated Report listing to Category 4c. An examination of water rights indicates that in Warm Creek proper (not including tributaries), there are at least 18 applied rights dating from the earliest record of 1889. Additional rights exist on Pole Creek, Trail Creek, Little Warm Creek, and other unnamed tributaries. Both the physical channel alterations (i.e., straightening) and hydromodifications support the change in listing to Category 4c as the sole cause for impairment and not meeting the identified BURP criteria.

Figure B24. Example of flumes and headgate structures.

Figure B25. Historic channel straightening along recent exclosure fenceline.

Figure B26. Partially obscured gate at bottom of photo (red arrow) and fencing on either side of the channel (black arrows).

Trail Creek – Trail Creek Pipeline Diversion to Mouth

ID17040204SK035_03

This AU is currently in Category 3 as an unassessed water. However, during the 2013 SEI examination, it was determined that Trail Creek was a sediment source to the Teton River when water was flowing. At the confluence of Trail Creek and the Teton River, there was an alluvial fan in the Teton River and a scour pool indicating various discharge regimes and sediment loads. The shape of the fan and the location of the scour pool were indicative of Trail Creek being the source. A TMDL for sediment was developed based on assumptions of when water is flowing.

In summer 2013, reconnaissance of Trail Creek found that the AU above the pipeline (ID17040204SK035_02) had water flow and appeared to be meeting beneficial uses based on a visual examination; however, the channel below the pipeline/diversions was dry and remained dry at every accessible location in a downstream direction.

The following photos document the low flow alteration and the unstable banks. This AU should be removed from Category 3 and listed in Category 4a for sediment/siltation and Category 4c for low flow alterations, as the stream is often completely dewatered.

Figure B27. Pipeline diversion structure.

Figure B28. Pipeline.

Figure B29. Secondary diversion structure (natural channel to right of headgate).

Figure B30. Erodible banks.

Figure B31. Banks with some vegetation and stabilization.

Figure B32. Trail Creek banks upstream of confluence with Teton River (limited flow velocity and assumed to be backwater from Teton River) (September 2013).

Figure B33. Trail Creek (April 2014) below the pipeline diversion, near Victor and Highway 33.

Dick Creek Spring Complex

ID17040204SK046_02

The Dick Creek Spring complex appears to have been a historical seep with some channelization in the wet meadows north of Darby Creek. However, it appears to have been heavily modified and channelized over the years and augmented with water from Darby Creek east of the highway.

The 1997 BURP monitoring location for this canal (1997SIDFL059) was not in the wetland/spring source location; therefore, the flow is determined to be augmentation from Darby Creek. This BURP location was near several road crossings/culverts and a now-defunct railroad grade. The BURP location was wedged between a railroad grade, the old highway, and a county road. Additional comments on the BURP form indicate that ditch diversion was within the reach.

Since the 1997 BURP monitoring there has been a new highway built upstream of the BURP site, and the railroad grade has been improved to become a bike trail. Additionally, a trench has been dug to the east of the new highway to improve water flow along (but not directly next to the new Highway 33) per the Teton County city engineer’s office.

This BURP location is not representative of Dick Creek Spring complex, which is primarily a wetland/seep area crisscrossed with irrigation canals. The 1997 BURP location was a minimally maintained canal and does not meet BURP monitoring criteria. Use of this location as representative of the AU was not warranted. Furthermore, BURP monitoring may not be possible as the representative areas in this AU are wet meadows and heavily modified for agricultural withdrawals—all of which do not meet the current BURP protocols and any interpretation based upon BURP results would be a measure of a canal and/or wetland function, which is outside the scope of BURP monitoring.

On April 10, 2014, the canal under Highway 33 was dry. On May 2, 2014, the canal remained dry and geocoded photos were taken documenting the lack of water in the canal. Photos (below) document the variable discharges and modified structure of the canal. It is recommended that the listing for this AU be moved from Category 5 (combined biota/habitat bioassessments) to Category 4c for low flow alterations as the sole cause of impairments.

Figure B34. Dick Creek (canal portion) near 1997 BURP location and Highway 33 in June 2013 (left) and May 2014 (right).

Figure B35. Yellow push-pin indicates 1997 BURP location, downgradient of old highway, railroad grade (now a bike trail), and the new Highway 33. Red arrow indicates the diversion/augmentation from Darby Creek. The blue arrow indicates the location where a recent trenched channel has been dug.

Appendix C. Sediment

The Idaho Department of Environmental Quality (DEQ) collected sediment data in 2013 to evaluate progress toward the surrogate sediment targets for instream erosion of at least 80% bank stability. The evidence supporting this surrogate sediment target is described in detail in the *Teton River Subbasin Assessment and Total Maximum Daily Load* (TMDL) (DEQ 2003a) and the *Supplement to the Teton River Total Maximum Daily Load – Moody, Fox, and Spring Creeks* (DEQ 2003b); both were approved by the US Environmental Protection Agency (EPA) in 2003.

In summary, the streambank erosion inventories are used to estimate background and existing streambank erosion derived from Natural Resources Conservation Service (NRCS) methods (a summary of the methods are included at the end of this appendix). DEQ measures the extent of eroding streambanks in key reaches of listed assessment units (AUs). Direct volume calculations of the excess sedimentation delivered by the eroding streambank area and lateral recession rate of the streambanks result in a measure of streambank stability. These calculations provide the current sediment load based on existing conditions and the natural background erosion rate, which is assumed to occur at 80% bank stability. The natural background erosion rate is considered the assimilative capacity, or load capacity, of the stream. The difference between the current load and the load capacity is the load reduction necessary for meeting the sediment TMDL (section 5.2).

Data summarizing the findings of the DEQ streambank erosion inventories and copies of the completed worksheets follow.

Streambank Erosion Inventory Method

The streambank erosion inventory (SEI) calculations are adapted and developed from a variety of sources and have been modified to better acquire the data needed by DEQ. The SEI method is used to determine bank stability and erosion levels with an end goal of determining if channel stability supports beneficial uses. The following material is included to illustrate where the methods were developed and to supply additional information to support the DEQ decision-making processes.

The SEI follows methods outlined in the proceedings from the Soil Conservation Service—now called the Natural Resources Conservation Service—Channel Evaluation Workshop (SCS 1983). The SEI method is a field-based methodology that measures streambank/channel stability, length of active eroding banks, and bank geometry (Stevenson 1994).

Streambank Stability—Lateral Recession Rate

The SEI method is used to estimate the long-term lateral recession rate. The recession rate is determined from field evaluation of six streambank characteristics that are assigned a categorical rating from -1 to 3 in 0.25 increments. The six scores are then summed for a total field stability score and corresponding lateral recession rate. The categories and rating scores are as follows:

Bank Erosion Evidence:

- Do not appear to be eroding—0

- Erosion evident—1
- Surface of bank is eroding and top of bank has cracking present—2
- Slumps and clumps sloughing off into stream (note size of clumps)—3

Bank Stability Condition:

- Very little unprotected bank, no undercut vegetation; **or** bank materials nonerosive—0
- Predominantly bare and unprotected, some rills, moderate undercut vegetation—1
- Almost bare, unprotected bank, rills, severely undercut vegetation, exposed roots—2
- Bare, numerous rills/gullies, severely undercut vegetation, trees or fences falling—3

Bank Cover/Vegetation:

- Predominantly covered with perennials **and/or** stable rock/bedrock—0
- 40% or less bare/erodible **and/or** cover is annual and perennials mixed—1
- 40% to 70% bare/erodible **and/or** cover is mostly annual vegetation—2
- Predominantly bare and erodible/no cover—3

Lateral Channel Stability:

- No evidence of significant lateral movement of channel—0
- Minimal/slight active lateral movement of channel—1
- Older channel shift, developing riparian vegetation on one or both banks—2
- Recent channel shift, no riparian vegetation present (oxbows, braided/anastomosed)—3

Channel Bottom Stability:

- Channel in bedrock/noneroding—0
- Soil bottom, gravels or cobbles, minor erosion—1
- Silt bottom, evidence of active downcutting—2

In-Channel Deposition:

- Deposition is stable and/or vegetated (more than this growing season), channel is aggrading— -1
- No evidence of recent deposition (includes all sizes of bedload-type materials)—0
- Mobile material in recent deposition, deposits will probably move down channel in next high flow—1

Score Summation

Erosion	Lateral Recession Rate
Slight (0–4)	0.01–0.05 feet per year
Moderate (4.25–8)	0.06–0.15 feet per year
Severe (8.25–11.75)	0.16–0.3 feet per year
Very Severe (12+)	0.31--0.5+ feet per year

The original method uses a "Score Summation" in broad categories as shown above as a descriptive estimation of lateral recession rate. Other streambank stability estimation methods exist, such as the simplified modification of Platts et al. (1983, p. 13) as stated in *Monitoring*

Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams (Bauer and Burton 1993). This method uses more descriptive terms of bank condition as an effort to make the assignment of lateral recession rate more objective.

However, DEQ prefers to calculate lateral recession rate directly from the stability scores identified in the field for more accurate results. Each total field score from 0 through 15 in 0.25 increments corresponds with a specific lateral recession rate ranging from 0.01 through 0.84 feet per year. The full recession rate table is included in the streambank erosion inventory spreadsheet, but a summary is given here:

Recession Rate Field Score	Lateral Recession Rate	Recession Rate Field Score	Lateral Recession Rate
0	0.01	8	0.15
1	0.02	9	0.16
2	0.03	10	0.27
3	0.04	11	0.38
4	0.05	12	0.5
5	0.06	13	0.61
6	0.09	14	0.73
7	0.12	15	0.84

The calculation process is the preferred choice by DEQ, as it is better suited to determine loading and reduction allocations necessary for total maximum daily load development.

Target stability scores, as opposed to field stability scores, are based on the need for additional erosion reductions beyond the overall 80% streambank stability. This additional parameter is to be used when there are excessive erosion rate indications, such as when the streambanks are prone to very severe erosion rates and need to be less erosive or the channel may anastomose or shift channels outside the current riparian corridor. The goal of this target stability score is to further promote options to meet an in-channel substrate of less than 28% fine sediments.

SEI—Total Bank Erosion Calculations

The direct volume method is used to calculate average annual erosion rates for a given stream segment based on the lateral recession rate determined in the survey (SCS 1983). The erosion rate (tons/mile/year) is used to estimate the total bank erosion of the selected stream corridor.

The direct volume method is summarized in the following equations:

$$E = [A_E \times R_{LR} \times_{BD}]/2{,}000 \text{ (pounds/ton)}$$

where:

E = bank erosion over sampled stream reach (tons/year/sample reach)

A_E = eroding area (square feet)

R_{LR} = lateral recession rate (feet/year)

${}_{BD}$ = bulk density of bank material (pounds per cubic feet)

The bank erosion rate (E_R) is calculated by dividing the sampled bank erosion (E) by the total stream length sampled:

$$E_R = E/L_{BB}$$

where:

E_R = bank erosion rate (tons/mile/year)

E = bank erosion over sampled stream reach (tons/year/sample reach)

L_{BB} = inventory/thalweg length

Total bank erosion is expressed as an annual average. However, the frequency and magnitude of bank erosion events are greatly a function of soil moisture and stream discharge (Leopold et al. 1964). Because channel erosion events typically result from above average flow events, the annual average bank erosion value should be considered a long-term average. For example, a 50-year flood event might cause 5 feet of bank erosion in 1 year, and over a 10-year period, this event accounts for the majority of bank erosion. These factors have less of an influence where bank trampling is the major cause of channel instability.

The *eroding area* (A_E) is the product of linear horizontal bank distance and average bank slope height. Bank length and slope heights are measured while walking along the stream channel. Laser distance rangefinders, paces, tape measures, or other tools are used to measure horizontal distance. Bank slope heights are continually measured and recorded over a given reach or site. The horizontal length is the length of the right or left bank or thalweg. Typically, one bank along the stream channel is actively eroding (e.g., the bank on the outside of a meander). However, both banks of channels with severe head cuts (i.e., nickpoints) or gullies will be eroding and are to be measured separately and will be eventually summed. The spreadsheet automatically accounts for sediment contributions based on inventoried segment inputs.

Soil *bulk density* (BD) is the weight of material divided by its volume, including the volume of its pore spaces. The BD of bank material can be measured visually in the field or estimated using methods similar to a Wolman pebble count to determine average particle size. Alternatively, a table of typical soil bulk densities can be used (see below), or soil samples can be collected and soil bulk density measured in the laboratory.

Soil Bulk Density Estimation Table

Soil Texture	Bulk Density (lb/ft^3)
Sands, loamy sands	110
Sandy loam	105
Fine sandy loam	100
Loams, sandy clay loams, sandy clay	90
Silt loam	85
Silty clay loam, silty clay	80
Clay loam	75
Clay	70
Organic	22

Note: Adapted from MDEQ (1999)

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Streambank Erosion Inventory Data Sheets

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	South Fork Moody Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040204SK006_02	***Upstream N***	43.688634
Segment Inventoried:	Abv confl Moody to abv ATV crossing	***W***	111.550764
Total Reach:	2500	***Downstream N***	43.692936
Date Collected:	24 June 2013 1100	***W***	111.553424
Field Crew:	C Cooper	**Notes:**	
Data Reduced By:	C Cooper		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	1	Single Bank	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	2500.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	110	lb/ft^3	Total Reach
Length of Similar Stream	79200	ft	Total Reach
Estimated Distance inventoried	2500.00	ft	"
Total Erosive Bank Length	475.00	ft	"
Percent Erosive Bank	19.0	%	"
Eroding Area (AE)	1650.00	ft^2	"
Lateral Recession Rate (RLR)	0.0475		"
Bank Erosion (E)	4.31	tons/year	"
Total Bank Erosion Rate (ER)	9.10	tons/mile/year	Reach and Segment
Total Bank Erosion	136.56	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	1.5	1.5
Bank Stability Condition (0 to 3)	0.5	0.5
Bank Cover/Vegetation(0 to 3)	0.5	0.5
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	0.25	0.25
In-Channel Deposition (-1 to 1)	0	0
Total = Slight (0-4); Moderate (4-8); Severe (>8)	3.75	3.75
Lateral Recession Rate (RLR) (ft/yr)	**0.0475**	**0.0475**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	1736.84	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	4.54	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	9.58	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	143.75	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
9.1	**136.6**	**9.6**	**143.7**	YES	**14**

Percent Erosion Reduction (%)	**5**
Total Erosion Reduction (tons/yr)	**7**

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	South Fork Moody Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040204SK006_02	***Upstream N***	43.674712
Segment Inventoried:	Fish Creek	***W***	111.55787
Total Reach:	1140	***Downstream N***	43.676853
Date Collected:	21 August 2013 1000	***W***	111.559443
Field Crew:	C Cooper & J Fales	**Notes:**	Deep gullies, added exclosures, but slow to recover
Data Reduced By:	C Cooper & J Fales		

Current Load Streambank Erosion Calculations		**Unit**	**Area Applied**
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	1140.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	110	lb/ft^3	Total Reach
Length of Similar Stream	15840	ft	Total Reach
Estimated Distance inventoried	2280.00	ft	"
Total Erosive Bank Length	1258.00	ft	"
Percent Erosive Bank	55.2	%	"
Eroding Area (AE)	4139.00	ft^2	"
Lateral Recession Rate (RLR)	0.5		"
Bank Erosion (E)	113.82	tons/year	"
Total Bank Erosion Rate (ER)	527.18	tons/mile/year	Reach and Segment
Total Bank Erosion	1581.53	tons/year	"

Recession Rate Calculations

Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	2.5	1.5
Bank Stability Condition (0 to 3)	2	1
Bank Cover/Vegetation(0 to 3)	2	1.5
Lateral Channel Stability (0 to 3)	2.5	1
Channel Bottom Stability (0 to 2)	2	0.5
In-Channel Deposition (-1 to 1)	1	0
Total = Slight (0-4); Moderate (4-8); Severe (>8)	12	5.5
Lateral Recession Rate (RLR) (ft/yr)	**0.5**	**0.075**

Load Capacity Streambank Erosion Calculations for Total Reach		**Unit**	**Area Applied**
Eroding Area at Load Capacity (AE)	1500.31	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	6.19	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	28.66	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	85.99	tons/year	Total Reach

Summary of Loads

Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
527.2	**1581.5**	**28.7**	**86.0**	**YES**	**9**

Percent Erosion Reduction (%)	**95**
Total Erosion Reduction (tons/yr)	**1504**

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	SF Moody Creek	Stream Segment Location (DD)	
Assessment Unit:	ID17040204SK006_02	*Upstream N*	43.685779
Segment Inventoried:	State Creek	*W*	111.557080
Total Reach:	1500	*Downstream N*	43.685982
Date Collected:	21-Aug-13	*W*	111.561300
Field Crew:	C Cooper & J Fales	Notes:	Banks stable (0.25 score) This SEI is specific for the silt filling pools and substrate from logging in upper section of the watershed
Data Reduced By:	C Cooper & J Fales		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	1	Single Bank	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	1500.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	26400	ft	Total Reach
Estimated Distance inventoried	1500.00	ft	"
Total Erosive Bank Length	1320.00	ft	"
Percent Erosive Bank	88.0	%	"
Eroding Area (AE)	2640.00	ft^2	"
Lateral Recession Rate (RLR)	0.09		"
Bank Erosion (E)	10.10	tons/year	"
Total Bank Erosion Rate (ER)	35.54	tons/mile/year	Reach and Segment
Total Bank Erosion	177.72	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0.5	0.25
Bank Stability Condition (0 to 3)	0.5	0.25
Bank Cover/Vegetation(0 to 3)	0.5	0.5
Lateral Channel Stability (0 to 3)	1.5	0.5
Channel Bottom Stability (0 to 2)	2	0.5
In-Channel Deposition (-1 to 1)	1	0
Total = Slight (0-4); Moderate (4-8); Severe (>8)	6	2
Lateral Recession Rate (RLR) (ft/yr)	**0.09**	**0.03**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	600.00	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.77	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	2.69	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	13.46	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
35.5	**177.7**	**2.7**	**13.5**	**YES**	**1**

Percent Erosion Reduction (%)	**92**
Total Erosion Reduction (tons/yr)	**166**

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Warm Creek - Canyon Creek Watershed	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040204SK011_02	***Upstream N***	43.746180
Segment Inventoried:	Warm Creek - Canyon Creek Watershed	***W***	111.388209
Total Reach:	800	***Downstream N***	43.747445
Date Collected:	24 June 2013 1530	***W***	111.389600
Field Crew:	C Cooper	**Notes:**	Hike to stream bottom through downed timber and old timber harvests-deposition former logging-most roads removed
Data Reduced By:	C Cooper		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	800.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	110	lb/ft^3	Total Reach
Length of Similar Stream	30500	ft	Total Reach
Estimated Distance inventoried	1600.00	ft	"
Total Erosive Bank Length	18.00	ft	"
Percent Erosive Bank	1.1	%	"
Eroding Area (AE)	7.00	ft^2	"
Lateral Recession Rate (RLR)	0.05		"
Bank Erosion (E)	0.02	tons/year	"
Total Bank Erosion Rate (ER)	0.13	tons/mile/year	Reach and Segment
Total Bank Erosion	0.73	tons/year	"

Recession Rate Calculations

Factor	Field Stability Score	Erosion Severity Reduction
Bank Erosion Evidence (0 to 3)	0	0
Bank Stability Condition (0 to 3)	0	0
Bank Cover/Vegetation(0 to 3)	0	0
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	2	2
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	4	4
Lateral Recession Rate (RLR) (ft/yr)	**0.05**	**0.05**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	124.44	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.34	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	2.26	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	13.05	tons/year	Total Reach

Summary of Loads

Current Load		Load Capacity			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
0.1	**0.7**	**2.3**	**13.0**	**No**	**1**

Percent Erosion Reduction (%)	**0**
Total Erosion Reduction (tons/yr)	**0**

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Trail Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040204SK035_03		Based on Float of Segment 1 (TR1 to Fox Creek) and upstream site visits (22Aug13)
Segment Inventoried:	Trail Creek		
Total Reach:	13200 ft		
Date Collected:	24-Sep-13		
Field Crew:	CCooper	**Notes:**	Estimated 75% of AU falls within this SEI grouping based on aerial photos NOTE: also 4C from canal
Data Reduced By:	C Cooper		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	1	Single Bank	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	13200	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	41554	ft	Total Reach
Estimated Distance inventoried	13200.0	ft	"
Total Erosive Bank Length	9900.0	ft	"
Percent Erosive Bank	75	%	"
Eroding Area (AE)	29700.0	ft^2	"
Lateral Recession Rate (RLR)	0.215		"
Bank Erosion (E)	271	tons/year	"
Total Bank Erosion Rate (ER)	109	tons/mile/year	Reach and Segment
Total Bank Erosion	854	tons/year	"

Recession Rate Calculations

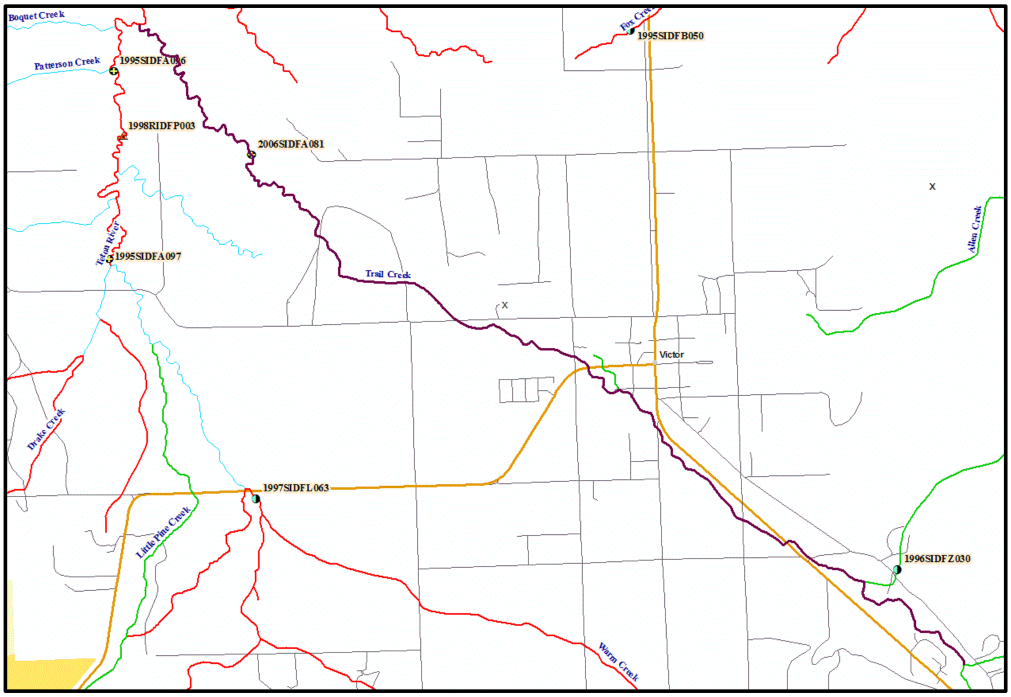
Factor	Field Stability Score	Erosion Severity Reduction
Bank Erosion Evidence (0 to 3)	2	1.5
Bank Stability Condition (0 to 3)	2	1.5
Bank Cover/Vegetation(0 to 3)	2	1.5
Lateral Channel Stability (0 to 3)	1.5	1
Channel Bottom Stability (0 to 2)	1	1
In-Channel Deposition (-1 to 1)	1	0.5
Total = Slight (0-4); Moderate (4-8); Severe (>8)	9.5	7
Lateral Recession Rate (RLR) (ft/yr)	**0.215**	**0.12**

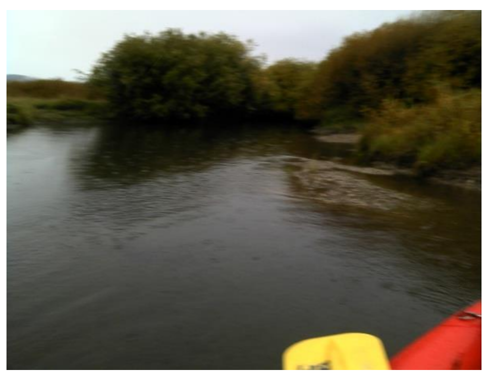
Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	7920	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	40	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	16	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	127	tons/year	Total Reach

Summary of Loads

Current Load		Load Capacity			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
109	**854**	**16**	**127**	**YES**	**13**

Percent Erosion Reduction (%)	**85**
Total Erosion Reduction (tons/yr)	**740**





Note: 2003 TMDL (Table 33) listed all of Trail Creek with streambank erosion at 2823 tons
This analysis does not include AU SK038_03 - Trail Creek

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Warm Creek - Trail Creek Watershed	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040204SK034_02	***Upstream N***	43.555596
Segment Inventoried:	Pole Creek	***W***	111.117973
Total Reach:	2000	***Downstream N***	43.560115
Date Collected:	25 June 2013 1330	***W***	111.119174
Field Crew:	C Cooper	**Notes:**	Signs of high velocity flows… may be storm driven
Data Reduced By:	C Cooper		

Current Load Streambank Erosion Calculations		**Unit**	**Area Applied**
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	2000.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	110	lb/ft^3	Total Reach
Length of Similar Stream	15840	ft	Total Reach
Estimated Distance inventoried	4000.00	ft	"
Total Erosive Bank Length	36.00	ft	"
Percent Erosive Bank	0.9	%	"
Eroding Area (AE)	30.00	ft^2	"
Lateral Recession Rate (RLR)	0.025		"
Bank Erosion (E)	0.04	tons/year	"
Total Bank Erosion Rate (ER)	0.11	tons/mile/year	Reach and Segment
Total Bank Erosion	0.33	tons/year	"

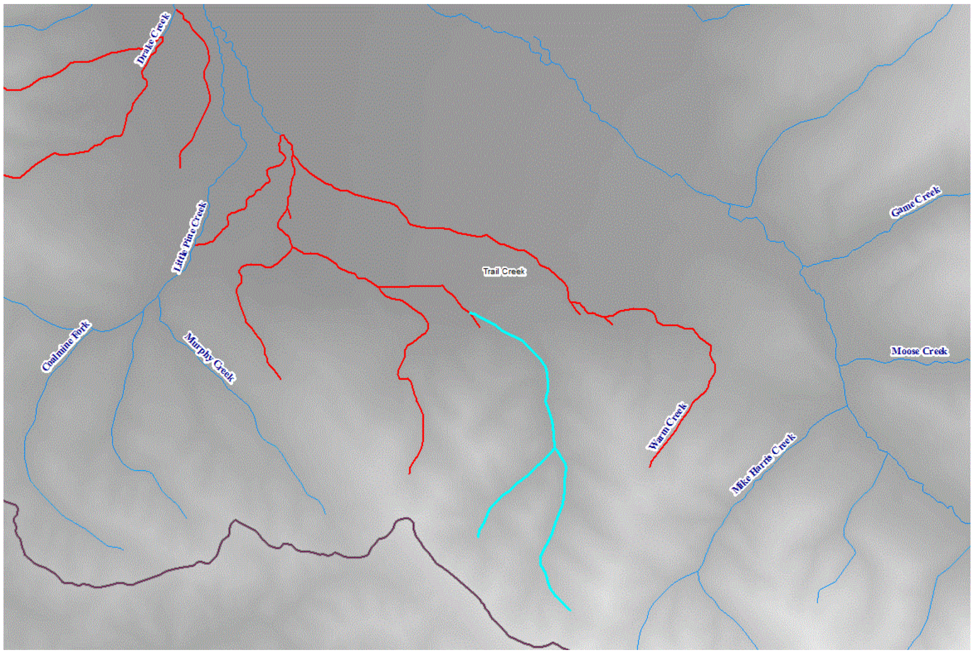
Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0.5	0.5
Bank Stability Condition (0 to 3)	0	0
Bank Cover/Vegetation(0 to 3)	0	0
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	0	0
In-Channel Deposition (-1 to 1)	0	0
Total = Slight (0-4); Moderate (4-8); Severe (>8)	1.5	1.5
Lateral Recession Rate (RLR) (ft/yr)	**0.025**	**0.025**

Load Capacity Streambank Erosion Calculations for Total Reach		**Unit**	**Area Applied**
Eroding Area at Load Capacity (AE)	666.67	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.92	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	2.42	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	7.26	tons/year	Total Reach

Summary of Loads

Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
0.1	**0.3**	**2.4**	**7.3**	**No**	**1**

Percent Erosion Reduction (%)	**0**
Total Erosion Reduction (tons/yr)	**0**


Drake Creek
Little Pine Creek
Trail Creek
Game Creek
Coalmine Fork
Murphy Creek
Moose Creek
Warm Creek
Mike Harris Creek

Teton River Erosion Inventory

Teton River – Headwaters to Harrops Bridge Sediment Summary

ID17040204SK028_03, SK026_04, SK020_04, and SK017_04

Three of these four AUs are listed as being sediment impaired (the lower segments) with sediment TMDLs developed in 2003. The uppermost AU was listed, along with the other three AUs, as having a substrate alteration leading to a Category 4c designation in 2003. However, there were no in-channel load estimations for the Teton River main stem (headwaters to the Highway 33 – Harrops Bridge) for any of these AUs. This document develops a TMDL for sediment for the uppermost AU (ID17040204SK028_03), in addition to supplementing sources, loads, and allocations previously developed.

This appendix summarizes the reasoning and methods used to calculate the streambank and substrate sediment load in the valley portion of the Teton River. These in-channel sediment sources to the river were not allocated in the 2003 TMDL. Assessing the sediment load in the Teton River had several unique problems

1. It is essentially not wadeable and was accessed via boat (which was the only method to effectively examine streambanks with limited access across private lands).
2. Contributions from tributaries necessitated that some sediment was potentially double counted (both in the tributary/hillslope erosion and deposits in the Teton River main stem).
3. The river dynamics and ground water interactions promote a seepage erosion/bank destabilization without identifiable anthropogenic causes.
4. There were multiple types and levels of erosion in the channel requiring multiple estimations and summations.
5. The deposition on the substrate required a separate estimation, mostly due to the size of the river, width-depth ratio, flow regime, and a combination of several of the above factors.
6. River BURP results found that the designated beneficial uses were all being met, except for the narrative sediment standard.

Therefore, the SEI methods were modified to account for the six factors above. The substrate sediment estimation is expected to be duplicative accounting for the sediment eroded upstream and deposited in channel, thereby adding to the margin of safety and ensuring a conservative approach. The readily mobilized substrate deposition of concern was estimated at 10% of the channel length.

A significant number of peer-reviewed articles discuss the sources of sediment in stream channels and from streambanks in support of the SEI approach. A selection of sources not included in the SEI protocol documentation is examined below.

The primary source is EPA's "Channel Processes: Streambank Erosion" website (*http://water.epa.gov/scitech/datait/tools/warsss/streamero.cfm*), which details processes leading to stream-channel erosion and was used to assist in identifying areas of concern in the Teton River. A study in Australia using cesium-137 isotopes to examine source material in the Murrumbidgee River found that a major source of sediment has an isotopic signature more related to the subsurface than the surface soil (Wallbrink et al. 1996). The study concluded that the topsoil contribution to total suspended sediment was <10% and the primary contributions were from the subsoil (i.e., streambanks) of smaller channels. The isotopic signature is based on determinations of cesium-137 deposition—which remains near the soil surface—from atmospheric testing of atomic weapons. Additional studies in Australia found that sediment from stream channel walls dominated the sediment in the headwaters of the Lachlan River, which has a land use heavily dominated by pasture (Smith and Dragovich 2007), which is directly relevant to many of the streams examined using DEQ's SEI method in which streambank erosion is identified as the primary sediment source.

Studies examining seepage-driven streambank instability have implicated changing ground water levels and surface water interactions as being a mechanism to drive erosion (Chu-Agor et al. 2008; Fox et al. 2007). Details of the role of subsurface flow on streambank erosion and the multiple stabilizing factors of vegetation are in Fox and Wilson (2010). Since streams in Idaho have extremely variable snowmelt-driven water levels and hydrology, the internal soil pore pressure combined with freeze-thaw cycles promote instream sloughing and fracturing. Mountain high-gradient stream channels typically exhibit greater channel stability in a downstream direction in the absence of complicating factors (e.g., changing lithologies) (Wohl 2000). Therefore, the smaller tributaries may be identified as having more potential instability, but that does not directly transfer to other channels further downstream. Bank stability is strongly related to vegetation-induced cohesion, and stream-channel instability is not directly related to stream equilibrium (Knighton 1998). Erosion and deposition in a channel can be the equilibrium state of the stream and therefore a natural process (Leopold and Wolman 1960; Langbein and Leopold 1966; Green et al. 1998). Overestimation of all instability as impairment is not an ideal mechanism, but it does imply a margin of safety to ensure that all sediment and erosion are examined to an extent that protects beneficial uses.

In 2013, a sediment survey of the upper Teton River found that the uppermost AU (SK028_03) had sufficient bank instability and fine particles on the substrate to warrant a TMDL. Since this AU transports its sediment load to downstream AUs with sediment impairments it also becomes a source. To improve the upper river corridor, it is essential to limit sediment influx to those AUs already listed as impaired. This approach includes the Trail Creek AU (ID17060204SK035_03—discussed separately in section 5.2), which is a sediment source to the Teton River when there is sufficient water in channel to mobilize the banks and in-channel sediment. The Trail Creek–Teton River confluence has a submerged alluvial fan that is partially eroded on the downstream portion of the Trail Creek portion, indicating that Trail Creek is the source of both the sediment deposition during lower flows and erosion/mobilization during higher flows. Limiting the sediment input from Trail Creek will improve conditions in the Teton River. As indicated in the 2003 TMDL, the Teton River is impaired by sediment, primarily from the cumulative effects of multiple sources, which is apparent from the number of identified load sources.

The major problem with identifying in-channel sediment loads in the Teton River is the fact that it is a highly sinuous river that alters its course naturally. This natural lateral movement is apparent in aerial photos with signs of old channels in the floodplain and the erosion of crescent shapes bordering the uplands. However, the width-depth ratio is not within the expected levels (IDFG 2013 and DEQ field observations), nor does the sinuosity have the expected erosion on the outside of the river bends with the deposition being on the inner portion. The natural sinuosity promotes alteration, as does the snowmelt peak discharges that are essentially still existent (meaning the river does not have dams providing flood/flow control), and the historic land-use promoted and accelerated bank erosion. The channel appears to have more deposition rather than entrenchment, therefore bank improvement and revegetation should promote the river system removing the fines and excess bedload in the substrate in the decade following improvements. This assumes that external loads become limited.

DEQ is meeting its obligations to develop TMDLs and assess for sediment impairment using the SEI protocols since they provide the required gross estimates of loads and a sufficiently large margin of safety to counter-balance the approach. The SEI method meets the requirements described in EPA's *Protocol for Developing Sediment TMDLs* (sections 3–7) (EPA 1999). Furthermore, federal regulations state that "load allocations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR 130.2(g)).

Since the Teton River naturally shifts its channel bed, development of the in-channel erosion rates is based on the assumption that the entire valley length is erodible. However, this assumption requires that different erosion rates be developed for each type of bank erosion. Percentages of bank eroding for each erosion type were summed to develop an AU by AU load. These erosion types include grass covered banks, "stable," trampled (low banks and high banks), inner and outer bends, willows (eroding and stable), etc. All these types and percentages were based on river floats in 2012 and 2013; however, the SK026_04 AU had two sets of metrics developed based on river access points and floating distances and are not necessarily related to changes in land-use patterns within the AU.

Of additional note is the erosion of the uplands in the SK017_04 AU where the river has once again meandered into the uplands and the "bank" is 10–50+ feet high and described as "cliffs" in this appendix. This is a natural erosion input but is included in the load calculations. This approach is deemed appropriate despite the following two factors since this source adds to the overall load. First, the erosion and source are natural and multiple crescents are visible from earlier meanders. Second, the material is a decomposed rhyolite, which does not have the same composition as the silt loams of the floodplains and thereby does not cause the same diminishment in substrate quality. However, the addition of the hillslope material does alter the width-depth ratios. This alteration to the habitat promotes a portion of the river to apparently be a more conducive environment than in the upstream portions for the Long-nose and Speckled Dace species, based on the 2012 river BURP scores. But the fine sediment particles are minimal in the overall substrate composition. This decomposed rhyolite environment changes below the Highway 33 Harrops Bridge as the river enters the canyon portion, which includes the failed Teton Dam and subsequent habitat and riverine alterations.

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Measurements of Eroding Banks for Teton River.

AU ID17040204SK028_03.

Type of Erosion	Percent AU	Length (ft)	Average Bank height (ft)	Bulk Density (lb/ft^3)
"Stable"	25.0	3432	1.0	85
Grasses	25.0	3432	1.5	85
Trample (low)	12.5	1716	1.0	85
Trample (high)	12.5	1716	3.0	85
Bend inner	6.3	858	0.5	85
Bend outer	6.3	858	2.0	85
Willows (s)	12.5	1716	1.5	85

AU ID17040204SK026_04

Type of Erosion	Percent AU	Length (ft)	Average Bank height (ft)	Bulk Density (lb/ft^3)
"Stable"	8.6	2521	1	85
Grasses	8.6	2521	1.5	85
Trample (low)	4.3	1261	1	85
Trample (high)	4.3	1261	3	85
Bend inner	2.2	630	0.5	85
Bend outer	2.2	630	2	85
Willows (s)	4.3	1261	1.5	85
Wetland	66	19219	0.5	85

AU ID17040204SK020_04

Type of Erosion	Percent AU	Length (ft)	Average Bank height (ft)	Bulk Density (lb/ft^3)
"Stable"	20.8	15045	1	90
Eroding	21.4	15510	3	90
Baseline grasses	14.2	10309	1.25	90
Trample	10.0	7244	1.75	90
Bend inner	15.0	10866	1.25	90
Bend outer	15.0	10866	2.5	90
Willows (e)	3.6	2600	1.5	90

AU ID17040204SK017_04

Type of Erosion	Percent AU	Length (ft)	Average Bank height (ft)	Bulk Density (lb/ft^3)
"Stable"	20.0	14700	1	100
Grasses	20.0	14700	2	100
Trample	15.0	11025	2	100
Bend inner	10.0	7350	0.5	100
Bend outer	10.0	7350	3	100
Willows (S)	14.0	10290	2	100
Willows (E)	10.0	7350	2.5	100
Cliffs	1	735	30	110

Examples of Erosion types:

Stable

Grasses

Trample—indicators

Eroding—generic slumps etc. assumed to be caused by ground water seepage

Trample—low

Trample—high

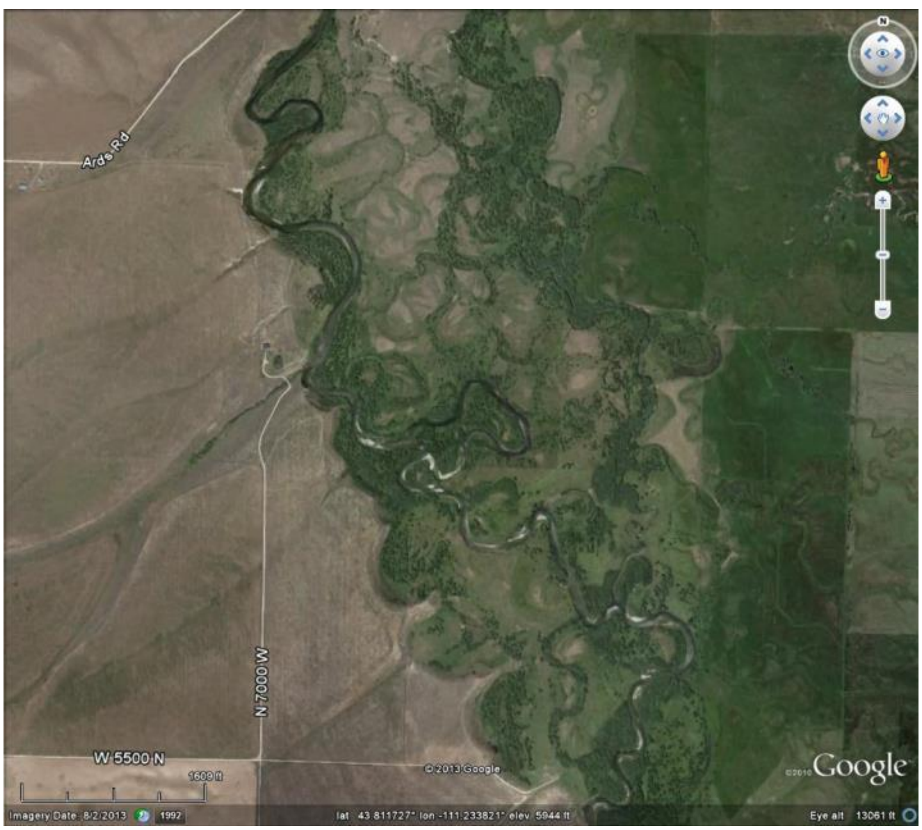
Bend—inner

Bend—outer

Willows—stable

Willows—eroding

Cliffs



Bank stabilization efforts

Teton River – Headwaters to Harrops Bridge Hillslope Sediment Summary

ID17040204SK028_03, SK026_04, SK020_04, and SK017_04

Based on observations of spring snowmelt and runoff dynamics across agricultural fields in the upper Teton River watershed, it appears that maintaining the current loads from upland sources is still relevant. While there are locations with sufficient active BMPs to limit soil transport and erosion, there are many locations with cropping methods and tillage patterns that contribute to soil loss. The two primary actions on the hillslopes that contribute to soil loss and sediment transport into streams and rivers are (1) tillage along the slopes and swales promoting rapid water movement (versus across the slope) and (2) removal or tilling-in of crop residue exposing the soils to erosive forces and aiding soil loss (this also includes wind erosion). The harsh conditions of snow pack, rain-on-snow events, and melting re-freezing cycles are accentuated by the frozen soil conditions that create an impermeable layer in the soil, just below the surface, that limits snowmelt/water infiltration into the soil. This in turn leads to increased overland flow, which can increase soil movement with some of the cropping/soil management techniques apparent in the subbasin.

However, there are exemplary locations with soil management that decreases the rill and gully erosion in the valley and is supportive of improved management. The silty-clay loam soils in the subbasin are readily mobilized if not held in place by vegetation/residue or contour tillage; there are insufficient fields with buffer strips and other BMPs to prevent sediment from reaching the stream and river channels. Based on the findings in the 2003 TMDL, it should be noted that significant efforts have been made to improve soil management and land-use activities, in particular in agriculture. However, based on the current observations and the scale of the subbasin, this process needs to continue before load reductions are met. Aggravating the process are poorly placed culverts under the roads with drops on the downgradient side promoting erosion (pool formation) through adding erosive energy to the water exiting the pipe. Pools on the upgradient side of roads do allow some sediment detention only so far as the residence time permits the silt to settle, but the placement of the opposite end of culvert pipe and associated drop adds erosive energy to the runoff. It is not expected that there is sufficient time for silts and clays to settle-out in these unintentional detention ponds.

These observations appear to be typical for the subbasin, and continuation of the loads set forth in the 2003 TMDL is recommended as the load reductions have not yet been met in many locations. Additional sediment TMDLs should be developed on a site-by-site basis and upland sources accounted for based on the dominant land-use and management techniques and susceptibility of streambanks to be eroded based on the topography and soil types.

Recent research has found that perennial filters strips, such as in the swale pictured below, serve to both capture sediment and remove nitrate from the system, thereby decreasing both from reaching rivers either through ground water or surface water (Helmers et al. 2012; Mitchell et al. 2015). This combination of factors has the potential to improve overall water quality within the Teton River subbasin.

References

Helmers, M.J., X. Zhou, H. Asbjornsen, R. Kolka, M.D. Tomer, and R.M. Cruse. 2012. "Sediment removal by prairie filter strips in row-cropped ephemeral watersheds." *Journal of Environmental Quality* 41(5): 1531–1539.

Mitchell, D.C., X. Zhou, T.B. Parkin, M.J. Helmers, and M. J. Castellano. 2015. "Comparing Nitrate Sink Strength in Perennial Filter Strips at Toeslopes of Cropland Watersheds." *Journal of Environmental Quality* 44(1): 191–199.

Examples of snowmelt and rill erosion on fields

Note the alluvial fan in pool above culvert (not shown photo bottom).

Note: Culvert and rill/gully erosion in swale, and drop out of culvert to field/swale.

Note rill erosion in swale with contour tillage but residue tilled-in.

Water entering a culvert/pipe from an upstream pool in field caused by a roadway. Note limited settling of fine soil particles, based upon water clarity entering the culvert-pipe.

Effective BMPs

Note limited drop outside of culvert and crop residue.

Note crop residue with contour tillage and across the swale. These management practices also appear to spread out the flow, increase infiltration, and limit rill erosion.

Note vegetated swale filter strip with different, presumably permanent, cropping pattern than areas to either side.

Teton River Erosion Inventory Data Sheets and Summary Tables

ID17040204SK017_04

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Teton River	Stream Segment Location (DD)	
Assessment Unit:	ID17040204SK017_04	Upstream N	Based on float of multiple stream segments
Segment Inventoried:	Multiple segments	W	
Total Reach:	72177 ft	Downstream N	
Date Collected:	25-Sep-13	W	
Field Crew:	T. Saffle, J. Fales, & C. Cooper	Notes:	Sum of 8 SEI segments
Data Reduced By:	C. Cooper		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	72177.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	100	lb/ft^3	Total Reach
Length of Similar Stream	72117	ft	Total Reach
Estimated Distance inventoried	144354.00	ft	"
Total Erosive Bank Length	73500.00	ft	"
Percent Erosive Bank	50.9	%	"
Eroding Area (AE)	152880.00	ft^2	"
Lateral Recession Rate (RLR)	0.16		"
Bank Erosion (E)	1223.04	tons/year	"
Total Bank Erosion Rate (ER)	89.47	tons/mile/year	Reach and Segment
Total Bank Erosion	1222.02	tons/year	"

Recession Rate Calculations

Factor	Field Stability Score	Erosion Severity Reduction
Bank Erosion Evidence (0 to 3)	2	1.5
Bank Stability Condition (0 to 3)	1	1.5
Bank Cover/Vegetation(0 to 3)	1	1.5
Lateral Channel Stability (0 to 3)	3	1.5
Channel Bottom Stability (0 to 2)	1	1
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	9	8
Lateral Recession Rate (RLR) (ft/yr)	**0.16**	**0.15**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	60051.26	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	450.38	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	32.95	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	450.01	tons/year	Total Reach

Summary of Loads

Current Load		Load Capacity			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
89.5	**1222.0**	**32.9**	**450.0**	YES	45

Percent Erosion Reduction (%)	**64**
Total Erosion Reduction (tons/yr)	**817**

ID17040204SK020_04

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Teton River	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040204SK020_04	***Upstream N***	Based on float of multiple stream segments
Segment Inventoried:	Multiple segments	***W***	
Total Reach:	82938 ft	***Downstream N***	
Date Collected:	25-Sep-13	***W***	
Field Crew:	T. Saffle, J. Fales, & C. Cooper	**Notes:**	Sum of 13 SEI segments
Data Reduced By:	C. Cooper		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	82938.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	90	lb/ft^3	Total Reach
Length of Similar Stream	82938	ft	Total Reach
Estimated Distance inventoried	165876.00	ft	"
Total Erosive Bank Length	72440.00	ft	"
Percent Erosive Bank	43.7	%	"
Eroding Area (AE)	129789.00	ft^2	"
Lateral Recession Rate (RLR)	0.16		"
Bank Erosion (E)	934.48	tons/year	"
Total Bank Erosion Rate (ER)	59.49	tons/mile/year	Reach and Segment
Total Bank Erosion	934.48	tons/year	"

Recession Rate Calculations

Factor	Field Stability Score	Erosion Severity Reduction
Bank Erosion Evidence (0 to 3)	2	1.5
Bank Stability Condition (0 to 3)	1	1.5
Bank Cover/Vegetation(0 to 3)	1	1.5
Lateral Channel Stability (0 to 3)	3	1.5
Channel Bottom Stability (0 to 2)	1	1
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	9	8
Lateral Recession Rate (RLR) (ft/yr)	**0.16**	**0.15**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	59439.21	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	401.21	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	25.54	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	401.21	tons/year	Total Reach

Summary of Loads

Current Load		Load Capacity			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
59.5	**934.5**	**25.5**	**401.2**	**YES**	**40**

Percent Erosion Reduction (%)	**59**
Total Erosion Reduction (tons/yr)	**573**

ID17040204SK026_04

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Teton River	Stream Segment Location (DD)	
Assessment Unit:	ID17040204SK026_04	*Upstream N*	Based on float of multiple stream segments
Segment Inventoried:	Multiple segments	*W*	
Total Reach:	29880 ft	*Downstream N*	
Date Collected:	25-Sep-13	*W*	
Field Crew:	T. Saffle, J. Fales, & C. Cooper	Notes:	Sum of 8 SEI segments
Data Reduced By:	C. Cooper		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	29880.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	29880	ft	Total Reach
Estimated Distance inventoried	59760.00	ft	"
Total Erosive Bank Length	29304.00	ft	"
Percent Erosive Bank	49.0	%	"
Eroding Area (AE)	24422.50	ft^2	"
Lateral Recession Rate (RLR)	0.16		"
Bank Erosion (E)	166.07	tons/year	"
Total Bank Erosion Rate (ER)	29.35	tons/mile/year	Reach and Segment
Total Bank Erosion	166.07	tons/year	"

Recession Rate Calculations

Factor	Field Stability Score	Erosion Severity Reduction
Bank Erosion Evidence (0 to 3)	2	1.5
Bank Stability Condition (0 to 3)	1	1.5
Bank Cover/Vegetation(0 to 3)	1	1.5
Lateral Channel Stability (0 to 3)	3	1.5
Channel Bottom Stability (0 to 2)	1	1
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	9	8
Lateral Recession Rate (RLR) (ft/yr)	**0.16**	**0.15**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	9961.02	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	63.50	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	11.22	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	63.50	tons/year	Total Reach

Summary of Loads

Current Load		Load Capacity			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
29.3	**166.1**	**11.2**	**63.5**	YES	**6**

Percent Erosion Reduction (%)	**63**
Total Erosion Reduction (tons/yr)	**109**

ID17040204SK028_03

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Teton River	Stream Segment Location (DD)	
Assessment Unit:	ID17040204SK028_03	*Upstream N*	Based on float of multiple segments
Segment Inventoried:	Multiple segments	*W*	
Total Reach:	13723 ft	*Downstream N*	
Date Collected:	25-Sep-13	*W*	
Field Crew:	T. Saffle, J. Fales, & C. Cooper	Notes:	Sum of 7 SEI segments
Data Reduced By:	C. Cooper		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flowpath distance)	13723.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	13723	ft	Total Reach
Estimated Distance inventoried	27446.00	ft	"
Total Erosive Bank Length	13728.00	ft	"
Percent Erosive Bank	50.0	%	"
Eroding Area (AE)	20163.00	ft^2	"
Lateral Recession Rate (RLR)	0.16		"
Bank Erosion (E)	137.11	tons/year	"
Total Bank Erosion Rate (ER)	52.75	tons/mile/year	Reach and Segment
Total Bank Erosion	137.11	tons/year	"

Recession Rate Calculations

Factor	Field Stability Score	Erosion Severity Reduction
Bank Erosion Evidence (0 to 3)	2	1.5
Bank Stability Condition (0 to 3)	1	1.5
Bank Cover/Vegetation(0 to 3)	1	1.5
Lateral Channel Stability (0 to 3)	3	1.5
Channel Bottom Stability (0 to 2)	1	1
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	9	8
Lateral Recession Rate (RLR) (ft/yr)	**0.16**	**0.15**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	8062.26	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	51.40	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	19.78	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	51.40	tons/year	Total Reach

Summary of Loads

Current Load		Load Capacity			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
52.8	**137.1**	**19.8**	**51.4**	YES	**5**

Percent Erosion Reduction (%)	**64**
Total Erosion Reduction (tons/yr)	**91**

Appendix D. Friends of the Teton River Monitoring Data

Table D1. FTR conductivity and pH measurements (2002–2013).

Variable	Site	Count	Mean	Minimum	Median	Maximum	Standard Deviation
Specific Conductivity (µS/cm)	DAR	39	182	119	169	273	44.8
	FISH	45	267	190	253	375	50.0
	FOX 1	45	329	260	305	428	57.9
	FOX 2	43	181	125	168	271	39.9
	SIX	46	314	230	290	449	68.2
	TC2	37	127	62	120	213	36.0
	TR1	49	306	100	306	443	73.6
	TR2	27	280	220	282	340	34.0
	TR3	50	288	182	286	414	52.2
	TR4	48	298	200	290	412	52.4
	WARM	45	328	100	320	453	66.0
	WOODS	44	280	185	258	392	56.2
pH (su)	DAR	39	8.1	6.7	8.2	9.1	0.57
	FISH	45	7.6	6.7	7.7	9.1	0.52
	FOX 1	45	7.8	6.7	7.9	8.8	0.45
	FOX 2	43	8.1	7.2	8.1	9.1	0.51
	SIX	46	7.5	6.4	7.7	8.8	0.53
	TC2	37	7.9	6.5	7.9	9.2	0.62
	TR1	49	8.0	6.5	8.0	8.8	0.44
	TR2	27	8.3	7.7	8.3	9.0	0.32
	TR3	50	8.0	6.8	8.1	8.8	0.48
	TR4	48	8.1	6.6	8.1	8.9	0.47
	WARM	45	7.9	6.1	8.0	8.7	0.50
	WOODS	44	7.9	6.7	7.9	8.8	0.49

Table D2. FTR dissolved oxygen, temperature, and turbidity measurements (2002–2013).

Variable	Site	Count	Mean	Minimum	Median	Maximum	Standard Deviation
Dissolved Oxygen (mg/L)	DAR	39	10.0	7.0	10.1	11.0	0.75
	FISH	45	9.0	7.0	9.0	12.4	1.08
	FOX 1	45	10.1	8.2	10.0	13.3	1.20
	FOX 2	43	10.0	8.8	9.9	11.9	0.75
	SIX	46	9.5	6.0	9.3	13.4	1.23
	TC2	37	10.0	7.0	10.2	12.0	0.96
	TR1	49	10.5	6.8	9.8	16.2	2.13
	TR2	27	10.4	7.7	9.7	14.1	1.97
	TR3	50	9.6	1.8	9.6	13.8	2.30
	TR4	48	9.3	2.7	9.6	12.8	1.84
	WARM	45	8.3	3.0	8.6	11.0	1.42
	WOODS	44	9.3	4.4	8.8	12.8	1.48
Temperature (°C)	DAR	39	6.1	3.2	6.0	10.9	1.66
	FISH	45	10.4	2.0	10.8	16.0	2.92
	FOX 1	45	11.0	5.7	11.4	14.1	1.90
	FOX 2	43	6.3	1.0	6.0	11.7	2.25
	SIX	46	8.7	1.2	9.0	11.2	1.77
	TC2	37	6.2	2.3	6.0	10.5	2.20
	TR1	49	10.1	0.5	11.0	17.0	3.29
	TR2	27	12.5	0.0	14.0	19.0	5.00
	TR3	50	11.5	0.0	12.0	18.0	4.77
	TR4	48	13.6	0.5	14.2	21.0	5.11
	WARM	45	14.6	9.0	15.0	19.0	2.52
	WOODS	44	11.0	0.0	11.0	19.0	4.35
Turbidity (NTU)	DAR	39	1.4	0.4	1.1	5.6	1.09
	FISH	45	5.6	0.7	4.4	33.6	5.65
	FOX 1	45	2.0	0.5	1.4	14.1	2.23
	FOX 2	43	3.1	0.3	1.4	29.2	5.56
	SIX	46	1.1	0.3	0.9	3.7	0.73
	TC2	37	4.5	0.4	1.6	68.4	11.40
	TR1	49	6.8	0.8	2.4	39.2	8.83
	TR2	27	7.2	0.7	3.4	27.0	7.88
	TR3	50	5.2	0.8	2.6	28.7	5.74
	TR4	48	4.0	1.0	2.3	28.9	4.78
	WARM	45	1.9	0.0	1.1	10.9	1.94
	WOODS	44	6.7	1.9	5.8	18.8	3.52

Table D3. FTR *Escherichia coli* measurements (2002–2013).

Variable	Site	Count	Mean	Minimum	Median	Maximum	Standard Deviation
E. coli (cfu/100 mL)	DAR	39	10	1	4	58	15.1
	FISH	45	311	4	124	2419	475.5
	FOX 1	45	118	1	44	770	185.2
	FOX 2	43	12	1	4	252	38.4
	SIX	46	94	2	24	837	187.6
	TC2	37	14	1	4	94	21.1
	TR1	49	355	4	220	2419	436.8
	TR2	27	130	4	74	884	187.3
	TR3	50	202	2	119	1414	289.5
	TR4	48	271	4	98	2419	430.2
	WARM	45	72	4	43	500	102.6
	WOODS	44	526	4	351	2419	560.8

Table D4. FTR nitrogen monitoring measurements (2002–2013).

Variable	Site	Count	Mean	Minimum	Median	Maximum	Count Below Detection	Standard Deviation
Ammonia:N (mg/L)	DAR	39	0.05	0.05	0.05	0.05	38	0.000
	FISH	45	0.05	0.05	0.05	0.07	43	0.003
	FOX 1	45	0.05	0.05	0.05	0.06	43	0.002
	FOX 2	43	0.05	0.05	0.05	0.05	39	0.000
	SIX	46	0.05	0.05	0.05	0.05	1	0.000
	TC2	37	0.05	0.05	0.05	0.05	44	0.000
	TR1	49	0.05	0.05	0.05	0.10	35	0.008
	TR2	27	0.07	0.05	0.05	0.21	44	0.036
	TR3	50	0.06	0.05	0.05	0.15	13	0.028
	TR4	48	0.06	0.05	0.05	0.13	35	0.020
	WARM	45	0.05	0.05	0.05	0.05	35	0.000
	WOODS	44	0.36	0.05	0.05	3.73	44	0.711
NO_2+NO_3:N (mg/L)	DAR	39	0.50	0.05	0.49	1.18	1	0.313
	FISH	45	0.89	0.14	0.72	2.01		0.497
	FOX 1	45	1.96	0.12	2.03	2.62		0.467
	FOX 2	43	0.51	0.05	0.47	1.78	2	0.365
	SIX	46	3.68	1.08	3.76	5.61		0.834
	TC2	37	0.44	0.05	0.44	1.10		0.315
	TR1	49	1.56	0.85	1.51	2.39	2	0.349
	TR2	27	1.33	0.52	1.40	1.80		0.311
	TR3	50	1.13	0.44	1.08	1.70		0.291
	TR4	48	0.91	0.14	0.86	1.94		0.351
	WARM	45	0.34	0.05	0.22	1.40		0.339
	WOODS	44	1.21	0.53	1.16	2.52	16	0.387

Table D5. FTR phosphorus monitoring measurements (2002–2013).

Variable	Site	Count	Mean	Minimum	Median	Maximum	Count Below Detection	Standard Deviation
Ortho-phos:P (mg/L)	DAR	39	0.05	0.01	0.05	0.05	18	0.013
	FISH	45	0.05	0.01	0.05	0.05	25	0.011
	FOX 1	45	0.05	0.01	0.05	0.05	24	0.011
	FOX 2	43	0.05	0.01	0.05	0.05	19	0.012
	SIX	46	0.05	0.01	0.05	0.05	1	0.011
	TC2	37	0.05	0.01	0.05	0.05	25	0.014
	TR1	49	0.05	0.01	0.05	0.05	16	0.011
	TR2	27	0.05	0.05	0.05	0.05	25	0.000
	TR3	50	0.05	0.01	0.05	0.08	22	0.013
	TR4	48	0.05	0.01	0.05	0.05	24	0.012
	WARM	45	0.05	0.01	0.05	0.05	23	0.011
	WOODS	44	0.13	0.04	0.11	0.52	25	0.106
T-phos:P (mg/L)	DAR	39	0.04	0.01	0.05	0.08	20	0.016
	FISH	45	0.05	0.01	0.05	0.10	20	0.020
	FOX 1	45	0.04	0.01	0.05	0.08	25	0.014
	FOX 2	43	0.05	0.01	0.05	0.37	20	0.055
	SIX	46	0.04	0.01	0.05	0.05	1	0.014
	TC2	37	0.04	0.01	0.04	0.10	27	0.018
	TR1	49	0.05	0.01	0.05	0.15	19	0.024
	TR2	27	0.05	0.05	0.05	0.06	24	0.003
	TR3	50	0.05	0.01	0.05	0.12	23	0.021
	TR4	48	0.04	0.01	0.05	0.12	26	0.019
	WARM	45	0.04	0.01	0.05	0.07	27	0.015
	WOODS	44	0.17	0.02	0.16	0.50	27	0.111

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Appendix E. Temperature

Salmonid spawning dates are based in part on the recommendations from the *Water Body Assessment Guidance* (Grafe et al. 2002) and *Teton River Investigations, Part III: Fish Movements and Life History 25 Years after Teton Dam* (Schrader and Jones 2004), which have complimentary spawning dates with the spawning period ending in mid-July.

Thermograph Abbreviations

MDMT maximum daily maximum temperature

MWMT maximum weekly maximum temperature

MDAT maximum daily average temperature

MWAT maximum weekly average temperature

DEQ-Collected Temperature Data

Table E1. Temperature monitoring locations by DEQ in the Teton River subbasin.

Water Body	Assessment Unit Number	IDASA Number	Monitoring Location
Teton River – Cache Bridge to Highway 33 Bridge	ID17040204SK017_04	2014SIDFTL0004	N 43.825007 W 111.233210
Teton River – Teton Creek to Cache Bridge	ID17040204SK020_04	2014SIDFTL0003	N 43.772144 W 111.203173
Teton River – Trail Creek to Teton Creek	ID17040204SK026_04	2014SIDFTL0002	N 43.639863 W 111.174670
Teton River – Warm and Drake Creeks Confluence to Trail Creek	ID17040204SK028_03	2014SIDFTL0001	N 43.624648 W 111.174920

DEQ 2014 Thermograph and Exceedance Table for Teton River (AU ID17040204SK017_04)

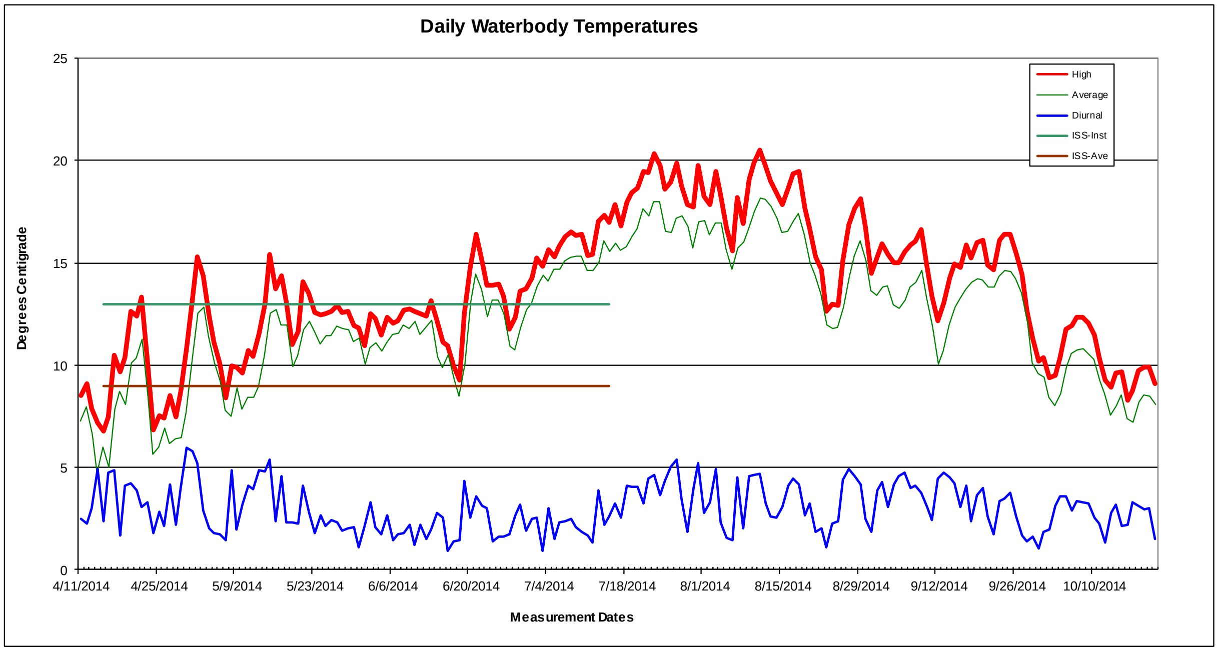
DEQ Summary of Temperature Data

Data Source: DEQ Idaho Falls Office
Water Body: Teton River
Data Collection Site: Harrops Bridge
Data Period: 4/11/2014 - 10/21/2014

MDMT = 20.5, 11 Aug
MWMT = 19.5, 27 Jul
MDAT = 18.2, 11 Aug
MWAT = 17.4, 15 Aug

HUC4 Number: 17040204
HUC4 Name: Teton

Waterbody ID Number: SK017_04



Idaho Salmonid Spawning Criteria Exceedance Summary			
	Exceedance Counts		
Criteria	Nmbr	Prcnt	
13 °C Instantaneous Spring	35	38%	
9 °C Average Spring	71	77%	
Spring Days Eval'd w/in Dates	92	15-Apr	15-Jul
13 °C Instantaneous Fall	0	0%	
9 °C Average Fall	0	0%	
Fall Days Eval'd w/in Dates	0	15-Nov	15-Nov
13 °C Instantaneous Total *	35	38%	
9 °C Average Total *	71	77%	
Tot Days Eval'd w/in Both Dates *	92		

DEQ 2014 Thermograph and Exceedance Table for Teton River (AU ID17040204SK020_04)

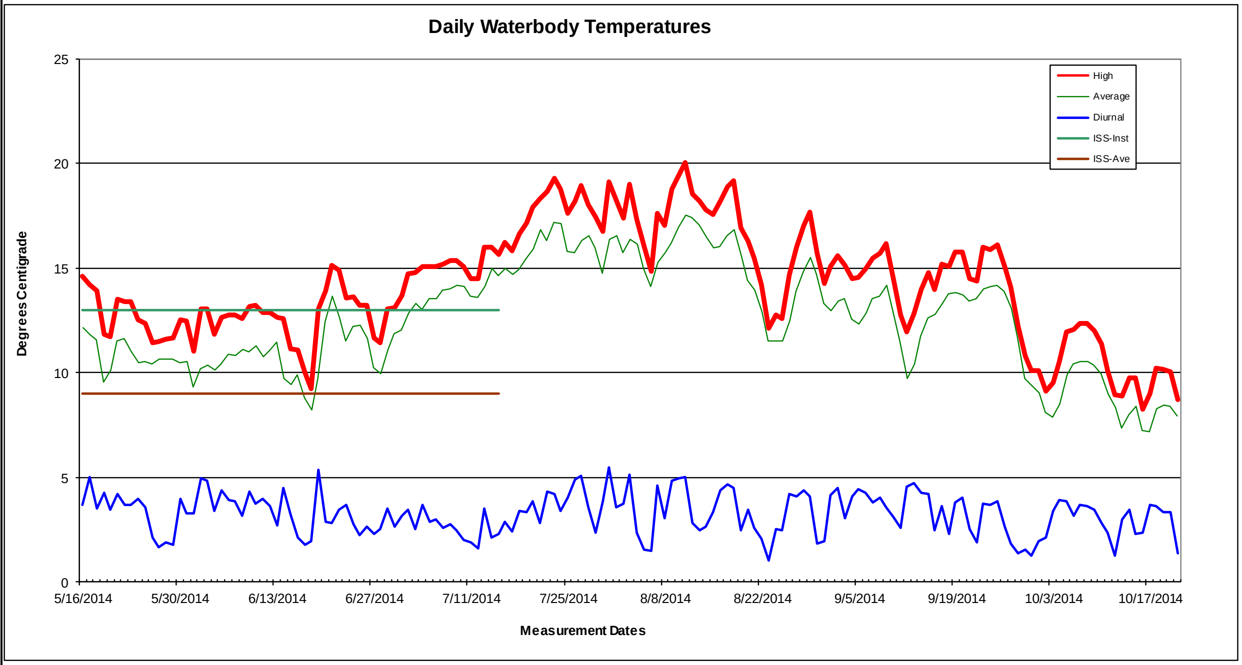
DEQ Summary of Temperature Data

Data Source: DEQ Idaho Falls Office
Water Body: Teton River
Data Collection Site: Old Highway
Data Period: 5/16/2014 - 10/21/2014

MDMT = 20.0, 11 Aug
MWMT = 18.6, 15 Aug
MDAT = 17.5, 11 Aug
MWAT = 16.8, 15 Aug

HUC4 Number: 17040204
HUC4 Name: Teton

Waterbody ID Number: SK020_04



Idaho Salmonid Spawning Criteria Exceedance Summary			
	Exceedance Counts		
Criteria	Nmbr	Prcnt	
13 °C Instantaneous Spring	35	57%	
9 °C Average Spring	59	97%	
Spring Days Eval'd w/in Dates	61	15-Apr	15-Jul
13 °C Instantaneous Fall	0	0%	
9 °C Average Fall	0	0%	
Fall Days Eval'd w/in Dates	0	15-Nov	15-Nov
13 °C Instantaneous Total *	35	57%	
9 °C Average Total *	59	97%	
Tot Days Eval'd w/in Both Dates *	61		

DEQ 2014 Thermograph and Exceedance Table for Teton River (AU ID17040204SK026_04)

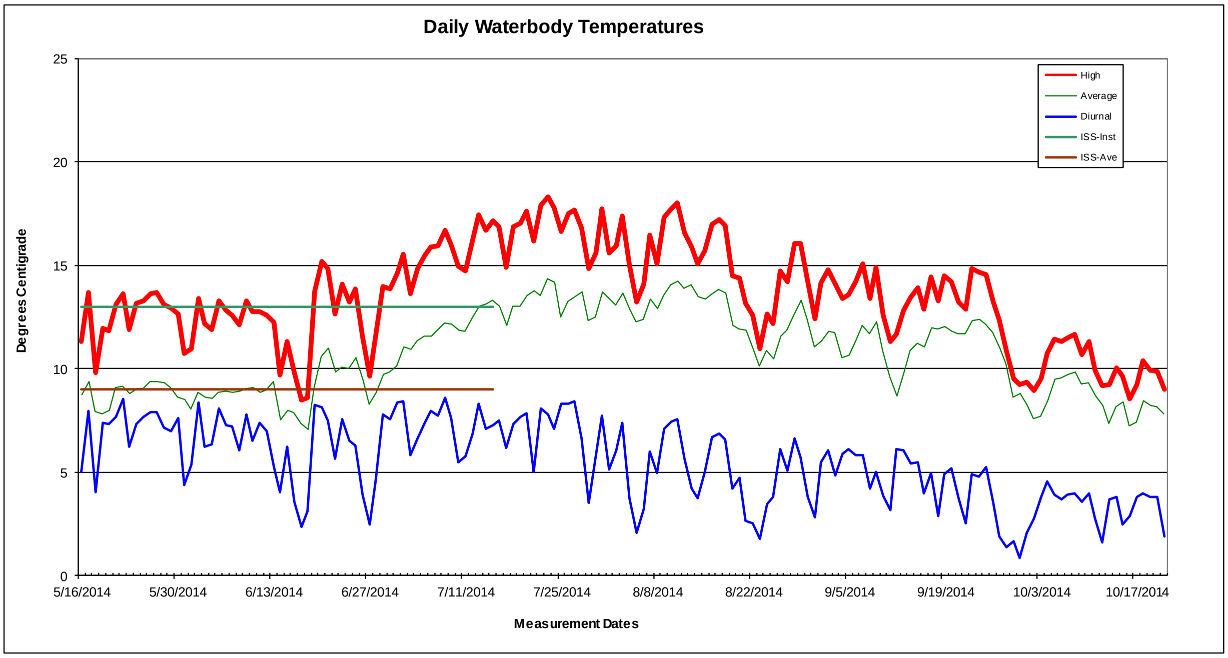
DEQ Summary of Temperature Data

Data Source: DEQ Idaho Falls Office
Water Body: Teton River
Data Collection Site: White Bridge
Data Period: 5/16/2014 - 10/21/2014

MDMT = 18.3, 23 Jul
MWMT = 17.5, 28 Jul
MDAT = 14.4, 23 Jul
MWAT = 13.8, 16 Aug

HUC4 Number: 17040204
HUC4 Name: Teton

Waterbody ID Number: SK026_04



Idaho Salmonid Spawning Criteria Exceedance Summary			
	Exceedance Counts		
Criteria	Nmbr	Prcnt	
13 °C Instantaneous Spring	34	56%	
9 °C Average Spring	37	61%	
Spring Days Eval'd w/in Dates	61	15-Apr	15-Jul
13 °C Instantaneous Fall	0	0%	
9 °C Average Fall	0	0%	
Fall Days Eval'd w/in Dates	0	15-Nov	15-Nov
13 °C Instantaneous Total *	34	56%	
9 °C Average Total *	37	61%	
Tot Days Eval'd w/in Both Dates *	61		

DEQ 2014 Thermograph and Exceedance Table for Teton River (AU ID17040204SK028_03)

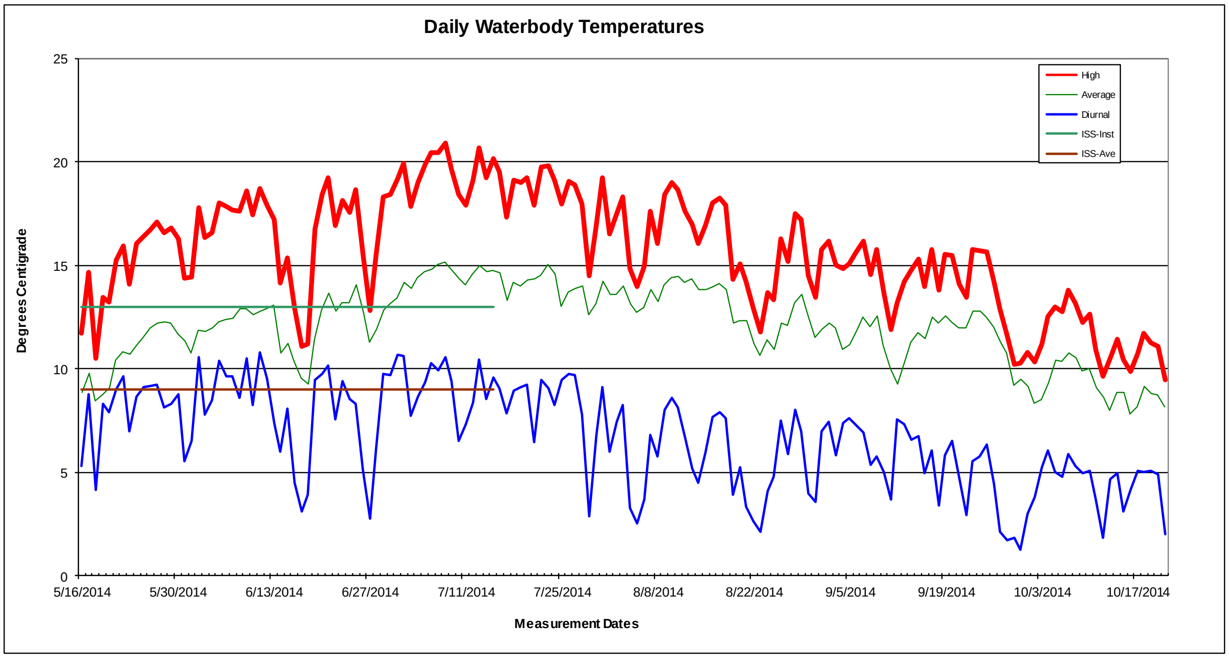
DEQ Summary of Temperature Data

Data Source: DEQ Idaho Falls Office
Water Body: Teton River
Data Collection Site: Below Warm-Drake confluence
Data Period: 5/16/2014 - 10/21/2014

MDMT = 20.9, 08 Jul
MWMT = 19.8, 10 Jul
MDAT = 15.2, 08 Jul
MWAT = 14.8, 10 Jul

HUC4 Number: 17040204
HUC4 Name: Teton

Waterbody ID Number: SK028_03



Idaho Salmonid Spawning Criteria Exceedance Summary			
	Exceedance Counts		
Criteria	Nmbr	Prcnt	
13 °C Instantaneous Spring	55	90%	
9 °C Average Spring	58	95%	
Spring Days Eval'd w/in Dates	61	15-Apr	15-Jul
13 °C Instantaneous Fall	0	0%	
9 °C Average Fall	0	0%	
Fall Days Eval'd w/in Dates	0	15-Nov	15-Nov
13 °C Instantaneous Total *	55	90%	
9 °C Average Total *	58	95%	
Tot Days Eval'd w/in Both Dates *	61		

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Appendix F. Data Sources

Table F1. Data and information sources for Teton River subbasin assessment.

Water Body	Data Source	Type of Data	Collection Date
Teton River and tributaries	Friends of the Teton River	Nutrients, physical parameters, restoration	2001–2013
Teton River	DEQ	Nutrients	2012
Teton River	DEQ	Sediment	2013
Throughout subbasin	DEQ	Bacteria	1993–2013
Throughout subbasin	DEQ	Sediment	2013
Teton River	DEQ	Temperature	2014
Teton Creek	DEQ	§319 funding	Variable
Teton River	US Bureau of Reclamation	Geomorphology	Variable
Teton River and tributaries	DEQ	Aerial photo interpretation	2015
Teton River and tributaries	DEQ	Solar Pathfinder	2014
Teton River	Idaho Department of Fish and Game	Fish counts	1985–2013
Throughout subbasin	Caribou-Targhee National Forest	Restoration, management activities	Variable
Throughout subbasin	DEQ	BURP	Variable
Teton River	DEQ	River BURP	2012
	Teton Regional Land Trust	Management activities and restoration	Variable
Spring Creek	Idaho Department of Water Resources	Water allocations	2013–2017
Throughout subbasin	US Bureau of Land Management	Management activities	Variable
Throughout subbasin	Natural Resources Conservation Service	Management activities	Variable

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Appendix G. Bacteria

The Idaho water quality standard was revised from fecal coliform to *E. coli* in 2006. A single *E. coli* sample should not exceed 576 *E. coli* organisms/100 mL for waters designated for secondary contact recreation or 406 *E. coli* organisms/100 mL for waters designated for primary contact recreation. If the single sample value exceeds these limits, the geometric mean shall be determined. An *E. coli* single instantaneous sample above the single sample values indicates a likely exceedance of the geometric mean but is not a violation of the water quality standards (IDAPA 58.01.02.251.01).

The geometric mean should not exceed 126 *E. coli* organisms/100 mL based on a minimum of 5 samples taken every 3 to 7 days over a 30-day period (IDAPA 58.01.02.251.01.a). This criterion supports both primary and secondary contact recreation.

The data sheet from the 1999 Warm Creek bacteria monitoring follows, as it supports the mis-listing of the Warm Creek (Canyon) AU (ID17040204SK011_02) for *E. coli*. Additional bacteria monitoring data sheets follow for 2010 and 2011. Data sheets contain locations outside of the Teton River subbasin.

Warm Creek (Canyon) *E. coli* monitoring 1999 at 1997SIDFL018.

State of Idaho, Department of Health and Welfare
Bureau of Laboratories - Pocatello Branch Lab
465 Memorial Drive, Pocatello, Idaho 83201
NON DRINKING WATER - BACTERIAL DENSITY REPORT

LAB: POCATELLO, Phone: (208) 233-4341
Branch Laboratory Supervisor, Bacteriology: Ardith Moran

IDEQ
STEVE ROBINSON
900 N. SKYLINE, SUITE B
IDAHO FALLS, ID 83402

Tracking Number: 60799-4959/
(Please Refer to this Tracking Number on any communications)

Grant/Project: 8709
BURP
Storet:
NPDES Number:
Matrix: WATER
Sample Location: WARM CK 97-L18 1997SIDFL018
Type of Sample: Surface
Sample Taken From: Creek - C
Collected by: DW
Preservation: Sodium Thiosulfate AND Cooled, 4½ C

Date Collected: 07/08/99 Date Received in Lab: 07/09/99
Time Collected: 18:10 Time Received in Lab: 14:30

Copy Sent To: DEQ, IDAHO FALLS OFFICE
êê

TEST CODE		RESULTS	COMPLETED
áááá		ááááááá	ááááááááá
EQT	TOTAL COLIFORM	1,730 /100 ml	07/12/99
EQM	E. COLI	40 /100 ml.	07/12/99
EMFC	FECAL COLIFORM (STORET # 31616)	40 /100 ml.	07/12/99

RECEIVED
JUL 13 [illegible]
DEQ-IDAHO FALLS

Teton River Monthly Bacteria Monitoring: Data Sheets

INTERMOUNTAIN ANALYTICAL SERVICES, INC.

IAS — ENVIRO CHEM
3314 Pole Line Road • Pocatello, Idaho 83201
Phone: (208) 237-3300 • Fax: (208) 237-3336
Email: iasec3308@iasenvirochem.com

EnviroChem

INDUSTRIAL - WATER - WASTE - SOIL - GEOCHEMICAL - FIRE ASSAY - QA/QC

Idaho Falls DEQ
Steve Robinson
900 N. Skyline, Suite B
Idaho Falls ID, 83402

Date Submitted: 6/23/2010
Date Reported: 6/25/2010

Certificate of Analysis

Sample Description: 204 - Warm 11-02
Sampling Date: 6/23/2010
Sampling Time: 07:15
Date Received: 6/23/2010
Lab Tracking #: I006159-01

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	26.2	MPN/100 mL	SM9223B	6/23/2010	BEN

Sample Description: 204 - NFK Moody 07-02
Sampling Date: 6/23/2010
Sampling Time: 08:30
Date Received: 6/23/2010
Lab Tracking #: I006159-02

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	52.9	MPN/100 mL	SM9223B	6/23/2010	BEN

Sample Description: 204 - Woods 50-02
Sampling Date: 6/23/2010
Sampling Time: 09:50
Date Received: 6/23/2010
Lab Tracking #: I006159-03

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	59.1	MPN/100 mL	SM9223B	6/23/2010	BEN

Sample Description: 204 - Warm 34-02
Sampling Date: 6/23/2010
Sampling Time: 10:15
Date Received: 6/23/2010
Lab Tracking #: I006159-04

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	193.5	MPN/100 mL	SM9223B	6/23/2010	BEN

Sample Description: 104 - Rainey 28-04
Sampling Date: 6/23/2010
Sampling Time: 10:45
Date Received: 6/23/2010
Lab Tracking #: I006159-05

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	29.4	MPN/100 mL	SM9223B	6/23/2010	BEN

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Email: iasec3308@iasenvirochem.com

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Idaho Falls DEQ
Aaron Swift
900 N. Skyline, Suite B
Idaho Falls ID, 83402

Date Submitted: 7/21/2010
Date Reported: 7/28/2010

Certificate of Analysis

Sample Description: Warm 11-02
Sampling Date: 7/21/2010
Sampling Time: 07:30
Date Received: 7/21/2010
Lab Tracking #: I007114-01

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	127.4	MPN/100 mL	SM9223B	7/21/2010	BWH

Sample Description: N FK Moody 07-02
Sampling Date: 7/21/2010
Sampling Time: 08:30
Date Received: 7/21/2010
Lab Tracking #: I007114-02

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	325.5	MPN/100 mL	SM9223B	7/21/2010	BWH

Sample Description: Woods 50-02
Sampling Date: 7/21/2010
Sampling Time: 09:30
Date Received: 7/21/2010
Lab Tracking #: I007114-03

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	920.8	MPN/100 mL	SM9223B	7/21/2010	BWH

Sample Description: Warm 34-02
Sampling Date: 7/21/2010
Sampling Time: 10:00
Date Received: 7/21/2010
Lab Tracking #: I007114-04

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	122.3	MPN/100 mL	SM9223B	7/21/2010	BWH

Sample Description: Rainey 28-04
Sampling Date: 7/21/2010
Sampling Time: 10:30
Date Received: 7/21/2010
Lab Tracking #: I007114-05

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	325.5	MPN/100 mL	SM9223B	7/21/2010	BWH

INTERMOUNTAIN ANALYTICAL SERVICES, INC.

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INDUSTRIAL - WATER - WASTE - SOIL - GEOCHEMICAL - FIRE ASSAY - QA/QC

Idaho Falls DEQ
Steve Robinson
900 N. Skyline, Suite B
Idaho Falls ID, 83402

Date Submitted: 8/26/2010
Date Reported: 8/27/2010

Certificate of Analysis

Sample Description: Warm 11-02
Sampling Date: 8/26/2010
Sampling Time: 08:00
Date Received: 8/26/2010
Lab Tracking #: I008198-01

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	517.2	MPN/100 mL	SM9223B	8/26/2010	MPH

Sample Description: N FK moody 07-02
Sampling Date: 8/26/2010
Sampling Time: 09:30
Date Received: 8/26/2010
Lab Tracking #: I008198-02

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	1553.1	MPN/100 mL	SM9223B	8/26/2010	MPH

Sample Description: Woods 50-02
Sampling Date: 8/26/2010
Sampling Time: 11:00
Date Received: 8/26/2010
Lab Tracking #: I008198-03

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	37.9	MPN/100 mL	SM9223B	8/26/2010	MPH

Sample Description: Warm 34-02
Sampling Date: 8/26/2010
Sampling Time: 11:30
Date Received: 8/26/2010
Lab Tracking #: I008198-04

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	770.1	MPN/100 mL	SM9223B	8/26/2010	MPH

Sample Description: Rainey 28-04
Sampling Date: 8/26/2010
Sampling Time: 12:30
Date Received: 8/26/2010
Lab Tracking #: I008198-05

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	66.9	MPN/100 mL	SM9223B	8/26/2010	MPH

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Idaho Falls DEQ
Steve Robinson
900 N. Skyline, Suite B
Idaho Falls, ID 83402

DateReported: 09/28/2010
Date Submitted: 09/29/2010

Certificate of Analysis

Sample Description: Warm 11-02
Sampling Date: 9/28/2010
Sampling Time: 09:00
Date Received: 9/28/2010
Lab Tracking #: I009213-01

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	195.6	MPN/100 mL	SM9223B	09/28/2010	GRP

Sample Description: N FK Moody 07-02
Sampling Date: 9/28/2010
Sampling Time: 10:00
Date Received: 9/28/2010
Lab Tracking #: I009213-02

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	64.4	MPN/100 mL	SM9223B	09/28/2010	GRP

Sample Description: Woods 50-02
Sampling Date: 9/28/2010
Sampling Time: 10:40
Date Received: 9/28/2010
Lab Tracking #: I009213-03

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	920.8	MPN/100 mL	SM9223B	09/28/2010	GRP

Sample Description: Warm 34-02
Sampling Date: 9/28/2010
Sampling Time: 11:00
Date Received: 9/28/2010
Lab Tracking #: I009213-04

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	231.0	MPN/100 mL	SM9223B	09/28/2010	GRP

Sample Description: Rainey 28-04
Sampling Date: 9/28/2010
Sampling Time: 11:20
Date Received: 9/28/2010
Lab Tracking #: I009213-05

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	4.1	MPN/100 mL	SM9223B	09/28/2010	GRP

Teton River Geometric Mean Bacteria Monitoring 2011: Data Sheets

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Idaho Falls DEQ
Steve Robinson
900 N. Skyline, Suite B
Idaho Falls, ID 83402

Date Submitted: 09/13/2011
Date Reported: 09/14/2011

Certificate of Analysis

Sample Description: Warm Creek 34
Lab Tracking #: I109078-01
Sampling Date/Time: 09/12/11 10:20

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	79.4	MPN/100 mL	SM9223B	09/13/2011	MPH

Sample Description: Woods Creek 50
Lab Tracking #: I109078-02
Sampling Date/Time: 09/12/11 11:10

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	488.4	MPN/100 mL	SM9223B	09/13/2011	MPH

Sample Description: Warm Creek 11
Lab Tracking #: I109078-03
Sampling Date/Time: 09/12/11 11:50

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	42.8	MPN/100 mL	SM9223B	09/13/2011	MPH

Sample Description: North Moody Creek 07
Lab Tracking #: I109078-04
Sampling Date/Time: 09/12/11 12:30

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	>2419.2	MPN/100 mL	SM9223B	09/13/2011	MPH

ND = Not Detected
All solids are reported on a dry weight basis unless otherwise noted.

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Page 1 of 1

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Idaho Falls DEQ
Steve Robinson
900 N. Skyline, Suite B
Idaho Falls, ID 83402

Date Submitted: 09/20/2011
Date Reported: 09/21/2011

Certificate of Analysis

Sample Description: Warm Creek 11
Lab Tracking #: I109132-01
Sampling Date/Time: 09/19/11 9:20

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	31.3	MPN/100 mL	SM9223B	09/20/2011	MPH

Sample Description: North Moody Creek 07
Lab Tracking #: I109132-02
Sampling Date/Time: 09/19/11 9:50

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	>2419.2	MPN/100 mL	SM9223B	09/20/2011	MPH

Sample Description: Woods Creek 50
Lab Tracking #: I109132-03
Sampling Date/Time: 09/19/11 11:10

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	150.0	MPN/100 mL	SM9223B	09/20/2011	MPH

Sample Description: Warm Creek 34
Lab Tracking #: I109132-04
Sampling Date/Time: 09/19/11 11:40

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	67.6	MPN/100 mL	SM9223B	09/20/2011	MPH

ND = Not Detected
All solids are reported on a dry weight basis unless otherwise noted.

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Idaho Falls, ID 83402

Date Submitted: 09/27/2011
Date Reported: 09/28/2011

Certificate of Analysis

Sample Description: Warm Creek 11
Lab Tracking #: I109198-01
Sampling Date/Time: 09/26/11 9:15

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	108.6	MPN/100 mL	SM9223B	09/27/2011	MPH

Sample Description: North Moody Creek 07
Lab Tracking #: I109198-02
Sampling Date/Time: 09/26/11 9:40

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	>2419.2	MPN/100 mL	SM9223B	09/27/2011	MPH

Sample Description: Woods Creek 50
Lab Tracking #: I109198-03
Sampling Date/Time: 09/26/11 10:50

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	461.1	MPN/100 mL	SM9223B	09/27/2011	MPH

Sample Description: Warm Creek 34
Lab Tracking #: I109198-04
Sampling Date/Time: 09/26/11 11:15

Analyte	Result	Units	Method	Analyzed	Analyst
E. coli	33.6	MPN/100 mL	SM9223B	09/27/2011	MPH

ND = Not Detected
All solids are reported on a dry weight basis unless otherwise noted.

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Laboratory Director

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Idaho Falls DEQ
Steve Robinson
900 N. Skyline, Suite B
Idaho Falls, ID 83402

Date Submitted: 10/04/2011
Date Reported: 10/05/2011

Certificate of Analysis

Sample Description: Warm Creek 11
Lab Tracking #: I110011-01
Sampling Date/Time: 10/03/11 9:05

Analyte	*Result*	*Units*	*Method*	*Analyzed*	*Analyst*
E. coli	50.4	MPN/100 mL	SM9223B	10/04/2011	MPH

Sample Description: Morth Moody Creek 07
Lab Tracking #: I110011-02
Sampling Date/Time: 10/03/11 9:35

Analyte	*Result*	*Units*	*Method*	*Analyzed*	*Analyst*
E. coli	435.2	MPN/100 mL	SM9223B	10/04/2011	MPH

Sample Description: Woods Creek 50
Lab Tracking #: I110011-03
Sampling Date/Time: 10/03/11 10:55

Analyte	*Result*	*Units*	*Method*	*Analyzed*	*Analyst*
E. coli	123.6	MPN/100 mL	SM9223B	10/04/2011	MPH

Sample Description: Warm Creek 34
Lab Tracking #: I110011-04
Sampling Date/Time: 10/03/11 11:15

Analyte	*Result*	*Units*	*Method*	*Analyzed*	*Analyst*
E. coli	47.3	MPN/100 mL	SM9223B	10/04/2011	MPH

ND = Not Detected
All solids are reported on a dry weight basis unless otherwise noted.

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Steve Robinson
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Date Submitted: 10/11/2011
Date Reported: 10/12/2011

Certificate of Analysis

Sample Description: Warm Creek 11
Lab Tracking #: I110051-01
Sampling Date/Time: 10/10/11 9:05

Analyte	*Result*	*Units*	*Method*	*Analyzed*	*Analyst*
E. coli	22.6	MPN/100 mL	SM9223B	10/11/2011	MPH

Sample Description: North Moody Creek 07
Lab Tracking #: I110051-02
Sampling Date/Time: 10/10/11 9:40

Analyte	*Result*	*Units*	*Method*	*Analyzed*	*Analyst*
E. coli	59.4	MPN/100 mL	SM9223B	10/11/2011	MPH

Sample Description: Woods Creek 50
Lab Tracking #: I110051-03
Sampling Date/Time: 10/10/11 10:55

Analyte	*Result*	*Units*	*Method*	*Analyzed*	*Analyst*
E. coli	59.4	MPN/100 mL	SM9223B	10/11/2011	MPH

Sample Description: Warm Creek 34
Lab Tracking #: I110051-04
Sampling Date/Time: 10/10/11 11:20

Analyte	*Result*	*Units*	*Method*	*Analyzed*	*Analyst*
E. coli	38.3	MPN/100 mL	SM9223B	10/11/2011	MPH

ND = Not Detected
All solids are reported on a dry weight basis unless otherwise noted.

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Appendix H. Beneficial Use Reconnaissance Program Monitoring Index Scores—DEQ Idaho Falls Regional Office

Beneficial Use Reconnaissance Program—Streams

Where the stream fish index (SFI) is blank (−), a fishing effort was not made and only the macroinvertebrate (SMI) and habitat (SHI) scores are available. If the average score of the indices is greater than or equal to 2, the AU is fully supporting cold water aquatic uses; if the average score is less than 2, the AU is not fully supporting. However, mitigating factors are also accounted for during the assessment process (e.g., nonrepresentative BURP site location).

BURP data 1998–2013

AU	BURP ID	Location Name	Date	Stream Macroinvertebrate Index		Stream Habitat Index		Stream Fish Index	
				Index	Condition	Index	Condition	Index	Condition
SK008_04	2011SIDFA037	Canyon Creek	8/4/2011	68	3	72	3	57	1
SK008_04	2013SDEQA225	Canyon Creek	7/29/2013	–	–	–	–	–	–
SK013_02	1998SIDFC004	Milk Creek	8/4/1998	35	1	49	1	–	–
SK021_03	1998SIDFC001	Horseshoe Creek	7/7/1998	50	1	57	1	25	0
SK022_03	1998SIDFC002	Horseshoe Creek	8/3/1998	72	3	77	3	81	3
SK038_03	1998SIDFC006	Trail Creek	8/4/1998	61	3	64	2	–	–
SK039_02	2004SDEQA008	Moose Creek	7/21/2004	59	2	73	3	53	1
SK039_02	2013SIDFA045	Moose Creek	8/6/2013	–	–	–	–	–	–
SK044_02	1998SIDFC003	Darby Creek	8/3/1998	66	3	37	1	–	–
SK053_03	1998SIDFC005	South Leigh Creek	8/4/1998	62	3	66	3	–	–

There were 25 BURP locations that could not be sampled (dry, no access, nonwadeable, etc.) between 1998 and 2014. There were approximately 80 locations monitored, or with a monitoring attempt, prior to 1998. Six sites were monitored in 2015, but a complete set of data for these site visits is not available at the time of writing this document.

Beneficial Use Reconnaissance Program—Rivers

Table H1. River BURP data—benthic.

Site	DEQ ID	Lab Benthic Chl-a ($ug\ L^{-1}$)	Area tested (cm^2)	Volume (L)	Benthic Chl-a ($mg\ m^{-2}$)
TR1	2012RDEQ001	380	72	0.5	26.4
TR2	2012RDEQ002	410	72	0.5	28.5
TR3	2012RDEQ003	340	72	0.5	23.6
TR4	2012RDEQ004	330	72	0.5	22.9

Table H2. River BURP data—macroinvertebrate and fishes.

DEQ ID	Location	RMI		SFI	
		Score	Condition	Score	Condition
2012RDEQA001	TR1	19	3	86	3
2012RDEQA002	TR2	17	3	91	3
2012RDEQA003	TR3	19	3	76	3
2012RDEQA004	TR4	23	3	76	3

Appendix I. Upper Teton River Beneficial Use Attainment Monitoring Program 2012

Introduction

This appendix is a supplement to the TMDL/SBA and does not contain all the applicable information nor is it designed to stand alone. This appendix relates the results of the study described below and the discussion section includes comparisons and analyses of the data collected and provided by FTR in conjunction with the data that were collected by DEQ personnel.

The Idaho Department of Environmental Quality (DEQ) is responsible for assessing Idaho's river and stream water quality. During the 2010 Integrated Reporting (IR) Cycle (aka 303d list), DEQ received a request from the group Friends of the Teton River (FTR) along with their data concerning the upper Teton Valley. FTR's request was to list sections of the Teton River as "Not Supporting Beneficial Uses," or "Impaired" due to nutrient enrichment. Chemical and physical data provided by FTR were used to justify their opinion of a nutrient impairment. FTR also requested that nitrogen be identified specifically as the impairing pollutant. This determination would trigger the development and implementation of a Total Maximum Daily Load (TMDL) in order to restore those uses to "fully supporting" status. DEQ declined to list the valley section of the Teton River as impaired on the 2010 303(d) list (aka Integrated Report), and instead committed to a robust sampling plan during the 2012 calendar year, conducted by DEQ Idaho Falls Regional staff and State Office staff.

In the *Teton River Subbasin Assessment and Total Maximum Daily Load* (DEQ 2003), the Teton River directly downstream of the valley section was identified as having nutrient enrichment and TMDLs were developed for nitrate and total phosphorus (TP). The selected nutrient levels were based upon an unpublished memo at DEQ that are currently (2014) not supported. The State of Idaho does not have numeric criteria for excess nutrients that are applicable to all waters in the state. Instead Idaho uses narrative criteria, that state "surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses" (IDAPA 58.01.02.200.06). Therefore, numeric data collected by sampling procedures are supplemental to identification of impairments, sources and pathways that can be directly related to nutrients. Collected numeric data are essential to development of a nutrient based TMDL if an impairment caused by nutrients were identified. Nutrient concentrations published in the literature are recommended values and do not trigger automatic TMDL/impairment status if measured values in the Teton River are greater than those published concentrations (e.g. EPA's Ecoregional Nutrient Criteria).

Several studies have examined the surface water and groundwater quality and dynamics in the upper Teton Valley. Groundwater analysis by Niklin (2003) found that the wells in the upper Teton Valley had NO_3 as N concentrations that averaged 1.07 mg L^{-1} in the shallow wells (<100 ft depth) nearest to the river. Similar results were found by Cosgrove and Taylor (2007), with analyses between 2002 and 2006 indicating variability within the wells with increasing or decreasing NO_3 as N concentrations. In 2013 Reisinger and Tank examined nutrient usage/uptake in biofilms in the Teton River. While the study found that the biofilms were either growth limited by P or co-limited by N and P there was concern that additional nutrient inputs could result in decreased biotic function leading to excessive growth. Chlorophyll-a (Chl-a) sampled off of inorganic substrata (i.e. periphyton growth on rocks) averaged 125 mg m^{-2} (+/- 3.6 mg m^{-2}) (Reisinger and Tank 2013).

The Montana Department of Environmental Quality (MDEQ) has spent considerable time and effort to determine nuisance level identification in streams and through public surveys identified a 150 mg m^{-2} Chl-a level as the threshold for growth before the general public determines a nuisance (Suplee et al. 2009). This nuisance level Chl-a was similar to Chl-a levels targeted in the Clark Fork River, MT to develop and implement nutrient controls with summertime mean Chl-a of 100 mg m^{-2} with a peak value of 150 mg m^{-2} (Suplee et al. 2012). MDEQ Chl-a target was less than the non-specific 200 mg m^{-2} proposed by Dodds and Welch (2000) for streams that are not turbid. In 2013, MDEQ proposed a statewide applicable nutrient standards that relate assessment data using Chl-a concentrations varying between 125 – 165 mg m^{-2}, this Chl-a is used to support the combined setting Total Nitrogen and Total Phosphorus concentrations to control eutrophication (Suplee and Watson 2013).

A review of in-stream processes in agricultural watersheds found that nitrate attenuation occurs primarily in the riparian zone (Ranalli and Macalady 2010). Additionally, groundwater nitrate sources were typically from local sources and flowed through riparian zones and that these zones have the potential to reduce nitrate inputs to the stream, especially under baseflow conditions (Ranalli and Macalady 2010). This finding suggests that actively growing and vegetated riparian zones are an effective means for nitrate removal. In associated research, Sheffield et al. (1997) found that off-channel stock watering decreases sediment and sediment attached nutrients transport to a stream channel. Stock (i.e. cattle) were found to prefer to drink from water troughs over 90% of the time, even when there were no fences to prevent access into the stream channel (Sheffield et al. 1997). Grazing and loafing in the riparian area was found to account for 72% of the suspended sediment and 55% of the total phosphorus in the stream, with the paths and loafing areas only accounting for less than 3% of the area with the stream buffer corridor (Tufekcioglu et al. 2013).

The *Teton River Subbasin Assessment and Total Maximum Daily Load* (DEQ 2003) identified a sediment yield of approximately 180,000 tons in the upper Teton Valley that led to TMDL development. However in-channel loads for the main stem of the Teton River were not quantified (DEQ 2003). In 2013, DEQ identified 8650 tons of sediment that are in-channel and can be readily mobilized. This sediment load is from bank erosion and substrate erosion/scour. The substrate available sediment is of unknown sources and is believed to be both from in-channel bank erosion and deposited from tributaries and uplands (see Appendix C).

The City of Driggs WWTP discharges into Woods Creek, which then flows approximately 2.9 miles before its confluence with the Teton River. The WWTP operates under NPDES permit #ID0020141 is the only permitted point source discharger above or within the Teton Valley segment. Recent and on-going upgrades (during the writing of this TMDL) to the wastewater facility should reduce the primary discharge concerns and the impacts to downstream receiving waters. Regular monitoring has confirmed that the facility is typically within permitted discharges; some exceedances have occurred during the upgrade process that is expected to remedy these events.

Objectives

DEQ’s primary objective was to examine beneficial use attainment and nutrient concentrations in the upper Teton River and determine if there were manifestations from the nutrient concentrations that led to impairments in those beneficial uses. DEQ intensively monitored the nutrient concentrations in the upper Teton River during the 2012 growing season. Additionally, DEQ monitored the status of the beneficial uses with the developed Beneficial Use Reconnaissance Program with modifications for rivers to base determinations of meeting beneficial uses in the river. Both data sets were examined to determine if there was a biologic response to the nutrients and if that response led to an impairment of beneficial uses as defined by the State of Idaho Administrative Code.

Location

The headwater portion of the Teton River, also known as the valley section, begins at the confluence of Warm and Drake Creeks and continues northward for approximately 26 miles, often through agricultural land, to the Highway 33 (Harrops) bridge (Figure I1). The upper Teton River channel is highly sinuous, low gradient and has remained connected to the floodplain and the water table. This river segment is historically prone to shifting banks and forming ox-bows and other riverine forms typical of this channel type. The river and most of the tributaries are essentially un-dammed, therefore the hydrograph is typical of a snow dominated river with peak flows occurring in mid- to late-June (USGS gage 13052200 – Teton River above South Leigh Creek near Driggs ID). Because of the snowmelt peak flows and dry summers there is a multiple foot difference in the stage/water level in the stream channel throughout the year. This drop in stage is compounded by water right applications and removal of water typically for irrigation and stock watering with many of the water rights only applied between spring and fall. In the winter, typically the river does freeze over in many locations and water levels and discharge are at their lowest. Additional information on the land-use, recreation and fisheries are contained in Section 1 and in the 2003 TMDL.

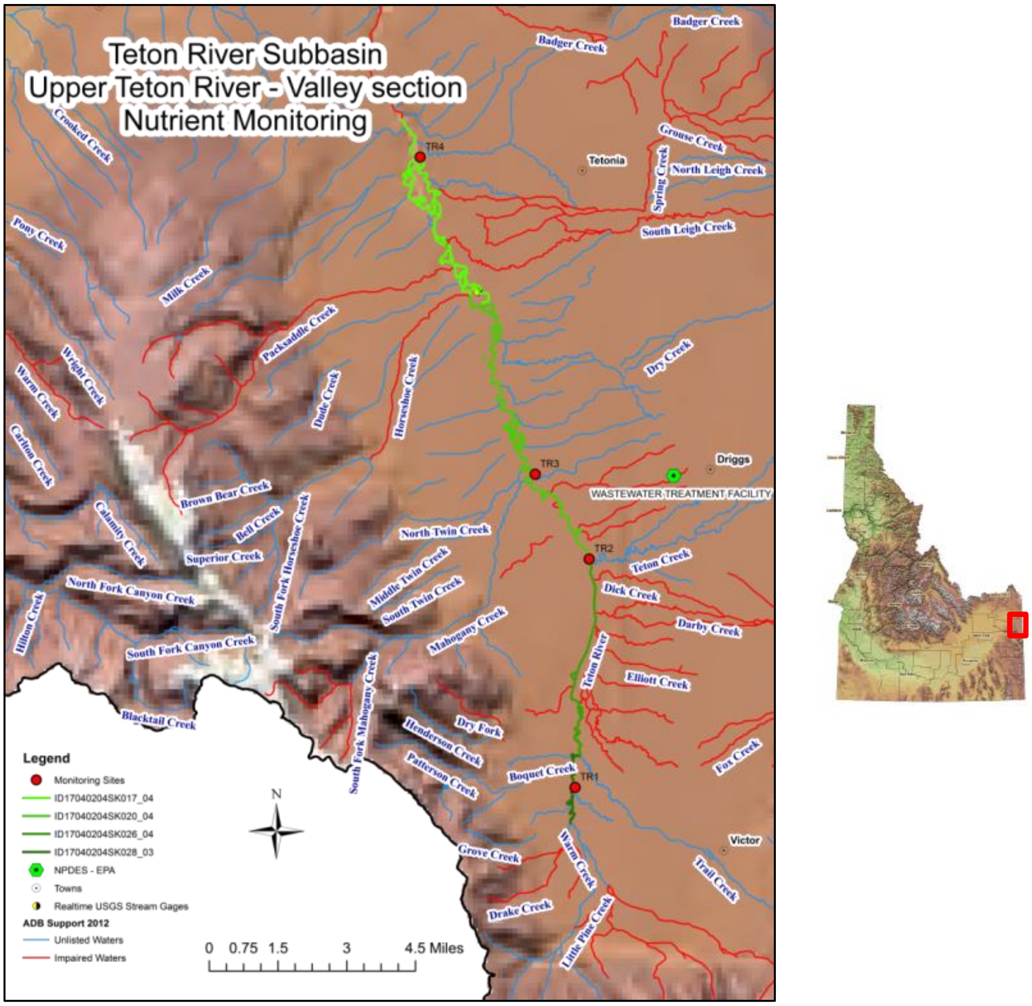


Figure I1. Map of the Upper Teton Valley, including sample locations. Note: eastern edge of map is approximately at the Wyoming-Idaho Stateline.

In 2012 there were 133,199 acres with active agricultural production in the Teton County with nearly 66% of the acreage in cropland, the primary crops being barley for grain (USDA 2012 Census of Agriculture. Accessed June 9, 2014: *http://www.agcensus.usda.gov/Publications/index.php*). In 1997, there were 138,331 acres in production (USDA 2002 Census of Agriculture. Accessed March 26, 2014: *http://www.agcensus.usda.gov/Publications/index.php*). Irrigated agriculture has been continuous in the valley since the late 1800's; there are significant diversions that remove water from the tributaries to the main stem of the Teton Valley. In the past, several tributaries have been entirely de-watered, but conservation efforts and improved irrigation practices returned water to several streams.

Four sample locations were identified, with a location representative of the management segments used by Idaho DEQ (i.e. Assessment Unit – AU). These locations are identified in a downstream direction as TR1 to TR4 and where initially identified by FTR (Figure I1). The TR4 location is at the lower end of the valley portion of the Teton River (Highway 33 at Harrops Bridge) and is upstream of the AUs with TMDLs developed for nutrients (DEQ 2003). The TR1 location was near the headwater of the Teton River below the confluence of Drake and Warm Creeks. TR2 was upstream of the Nickerson bridge crossing, below the confluence of Teton Creek. TR3 was located at the Bates Bridge directly east of the city of Driggs, Idaho and below Woods Creek, in which the city discharges their treated WWTP effluent. It should be noted that FTR discontinued monitoring at the TR2 at the end of 2005 as they found the added costs of the station did not provide commensurate information when compared to the TR3 station approximately 3.6 river miles downstream.

Methods

DEQ collected water column chemistry, dissolved oxygen, chlorophyll-a, visual algal density, and percent eroding bank. All samples were collected according to standard methods consistent with Environmental Protection Agency (EPA) methodology, where applicable. Water chemistry parameters included: total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate + nitrite as nitrogen (NO_3 + NO_2 as N), and chlorophyll-a (Chl-a). Estimations of Total nitrogen concentrations were calculated by adding the NO_3 + NO_2 as N and TKN.

Using standard protocols, water samples were collected from flowing water in the stream at a well-mixed representative location in pre-acidified (H_2SO_4) HDPE bottles. At least one de-ionized water blank and/or duplicate were collected on every sample date and were included with the complement of quality assurance samples. All samples were stored in a cooler, on ice, and immediately transferred to a designated refrigerator upon return to the laboratory. These samples were preserved in the field and delivered on ice to the laboratory. The NO_3 + NO_2 as N detection limit was 0.01 mg L^{-1} and the TP detection limit was 0.005 mg L^{-1}. Chlorophyll-a samples were collected in triple rinsed HDPE bottles. All samples were stored on ice and immediately transferred to a designated refrigerator upon return to the laboratory. In the lab Chl-a samples were filtered through GF/C 47mn glass microfibre filters and preserved with a $MgCO_3$ solution following standards methods. Filter papers were folded, wrapped in foil and frozen. Frozen filter paper samples were overnight shipped between ice packs to the Idaho Bureau of Laboratories in Boise, ID, along with the acid preserved water samples.

DEQ also collected data as outlined in the *Draft Beneficial use reconnaissance program field manual for Rivers* (River BURP) (DEQ 2010) and assessed using the Idaho River Ecological Assessment Framework (Grafe 2002) at four reaches representative to the relevant assessment unit (AU). Data are primarily of a biologic nature and composed of electrofishing, macroinvertebrate sampling (kick-net), river characteristics (including width, depth, bankfull etc.), chlorophyll-a (benthic and water column), land-use and other data. Samples collected were processed and preserved the day of collection and maintained at 4^oC or frozen until delivery to the Idaho Bureau of Laboratories in Boise, ID. Periphyton samples were collected at 6 locations at each reach from a 12 cm^2 hard submerged surface and combined in a 500 mL bottle, later filtered and preserved. Method details are in Draft *Beneficial use reconnaissance program field manual for rivers* (DEQ 2010). The metrics and approaches to assess condition are from Grafe (2002) and were used to determine the status of the beneficial uses in the upper Teton River. These metrics are based upon compiled analyses of multiple river conditions in Idaho consisting of reference and stressed locations and collected data. Both approaches used are similar to the methods used in wadeable streams in Idaho, but adapted to account for scale.

Portable meters, Yellow Springs Instruments Sondes (YSI 6920), were used to measure field parameters, pH, temperature, specific conductivity, and dissolved oxygen. Calibrations were performed before each use according to manufacturer methods. YSI 6920 sondes were deployed in the Teton River at the TR1 and TR4 locations. These were deployed on July 16, 2012 and retrieved on September 26, 2012. Field calibrations occurred regularly, along with confirmation measurements from a third YSI 6920.

Statistical data analyses were examined using Minitab 16 (Minitab 16 Statistical Software. 2010. [Computer software]. State College, PA: Minitab, Inc. www.minitab.com). Comparisons between locations used a Kruskall-Wallis test (similar to ANOVA – but not dependent upon the normality of the data). Trends were examined using WQStats Plus (Release 1.56, NIC Environmental Division, Carmel, IN, USA) and determination of statistical significance is based upon the non-parametric Sen's Slope estimator. Significant trends are given with the corresponding alpha value instead of the calculated Mann-Kendall statistic. The Mann-Kendall test is a linear regression zero slope test of time-ordered data over time (Gilbert 1987).

Available data from Friends of the Teton River were collected between 2002 and 2012 on approximately a quarterly basis. Collection methods used standard methods and results were delivered to DEQ as part of the Integrated Report call for data.

Results

Early season monitoring occurred on a monthly basis at the 4 stations and was used to develop the methods and sample sites along with collecting baseline data. Since the study objective was directed at the growing season, these sample dates are included to describe the hydrology and potential dilution/entrainment effects of the pre-snowmelt hydrograph. The peak discharge occurred on June 6, 2012, this is believed to be related to rain on snow events followed by cooler weather, but the snowmelt dominated discharges lasted until approximately June 20, 2012 when the recession limb of the hydrograph is apparent (Figure I2). It was determined that the June 28, 2012 sample date was on the tail end of the falling limb of the snowmelt hydrograph and for statistical purposes was included in this analysis. This is also true for sample dates after the proposed growing season end-date of September 30, 2012 as the weather remained warm. Figure I2 includes the daily maximum, minimum and daily average discharges for the USGS gage period of record to provide context for 2012 (USGS 2013, Accessed 24 December 2013, *http://waterdata.usgs.gov/usa/nwis/nwisman/?site_no=13052200&agency_cd=USGS*, Confirmed 2 April 2014) and sample date location on the annual hydrograph.

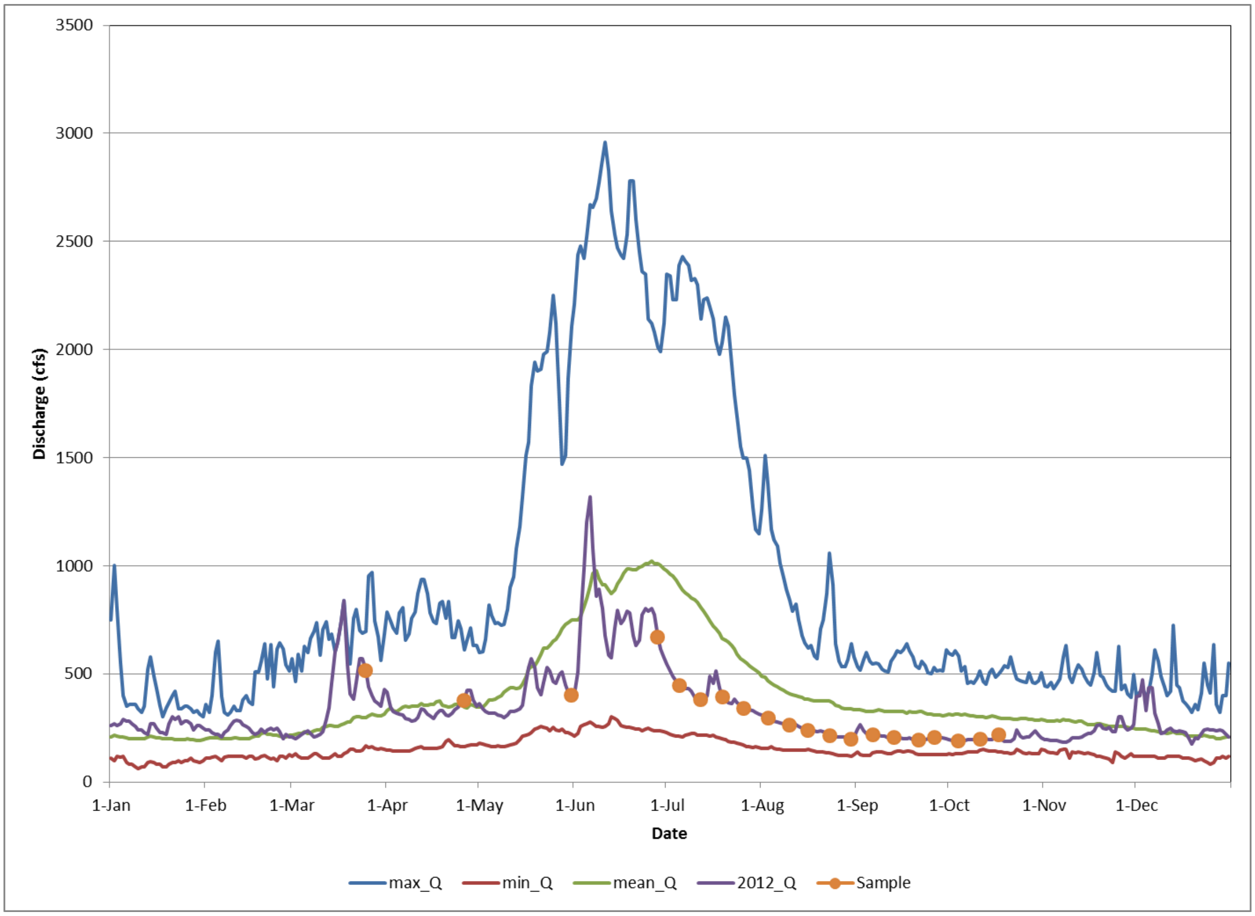


Figure I2. Discharge 2012 with sample dates, at USGS stream gage 13052200 – Teton River above South Leigh Creek near Driggs, ID. Includes the daily maximum, minimum and daily average discharges for the USGS gage period of record

In 2012 the discharge peaked in June, followed by multiple peaks and then from late June until the end of the study period the hydrograph tail slowly decreased to baseflow conditions, with the exception of storm event related peaks (Figure I2). By early September discharge in the river was near baseflow conditions (approximately 200 cfs). Precipitation at the Driggs airport indicates that there were two storms (each exceeding 1 inch precipitation) that directly correlate to changes in the hydrograph (Western Regional Climate Center 2014, Accessed 28 January 2014, *http://www.wrcc.dri.edu/summary/Climsmsid.html*, Confirmed 2 April 2014). On 16 July 2012 approximately 1.1 inches of precipitation occurred, whereas on roughly 14 September approximately 1.3 inches of precipitation occurred. Smaller storm events had representatively smaller peaks. The hydrograph is typical of a snow dominated climate for an un-dammed river. Irrigation withdrawals do alter the hydrograph during baseflow/growing season, and there are additional stock watering withdrawals that are active annually but volumes are minimal in comparison with the irrigation withdrawals.

Early season monitoring data, combined with the hydrograph, indicate that there were dilutional stormflows reducing the measured $NO_3 + NO_2$ as N concentrations. Early season valley bottom snowmelt and rain-on-snow storm events appear to entrain and mobilize TP, and appears to cause a TKN “first flush” that is not identified in the later pre-snowmelt monitoring as these later concentrations are below the monitoring average (Figure I2 and Table I1). The greatest single measured NO_3 + NO_2 as N concentration was measured at the upper central location (TR2) in April and is anomalous and not believed to be representative of the overall river quality on that date (Table I1 and Figure I3).

Table I1. Chemical monitoring descriptive statistics 2012.

Variable	Unit	Location	N	Mean	Median	StDev	Variance	Minimum	Maximum
TKN	(mg/L)	TR1	20	0.34	0.34	0.11	0.01	0.17	0.71
		TR2	20	0.37	0.35	0.13	0.02	0.21	0.79
		TR3	20	0.43	0.40	0.14	0.02	0.23	0.80
		TR4	20	0.37	0.38	0.10	0.01	0.23	0.63
NO2+NO3:N	(mg/L)	TR1	20	1.05	1.10	0.32	0.10	0.01	1.30
		TR2	20	0.85	0.74	0.49	0.24	0.48	2.70
		TR3	20	0.90	0.94	0.14	0.02	0.54	1.00
		TR4	20	0.56	0.70	0.21	0.04	0.23	0.84
Total N	(mg/L)	TR1	20	1.39	1.46	0.27	0.07	0.66	1.66
		TR2	20	1.22	1.07	0.52	0.27	0.74	3.02
		TR3	20	1.33	1.36	0.11	0.01	0.97	1.48
		TR4	20	0.94	0.99	0.21	0.04	0.58	1.22
TP	(mg/L)	TR1	20	0.027	0.018	0.022	0.000	0.013	0.100
		TR2	20	0.019	0.012	0.021	0.000	0.010	0.099
		TR3	20	0.031	0.024	0.022	0.001	0.016	0.095
		TR4	20	0.022	0.016	0.016	0.000	0.010	0.068
Chl-a	(ug/L)	TR1	15	0.86	0.79	0.37	0.14	0.22	1.70
		TR2	14	0.93	0.85	0.52	0.27	0.22	2.30
		TR3	14	2.34	1.80	2.24	5.00	0.82	10.00
		TR4	15	1.56	1.60	0.52	0.27	0.55	2.30

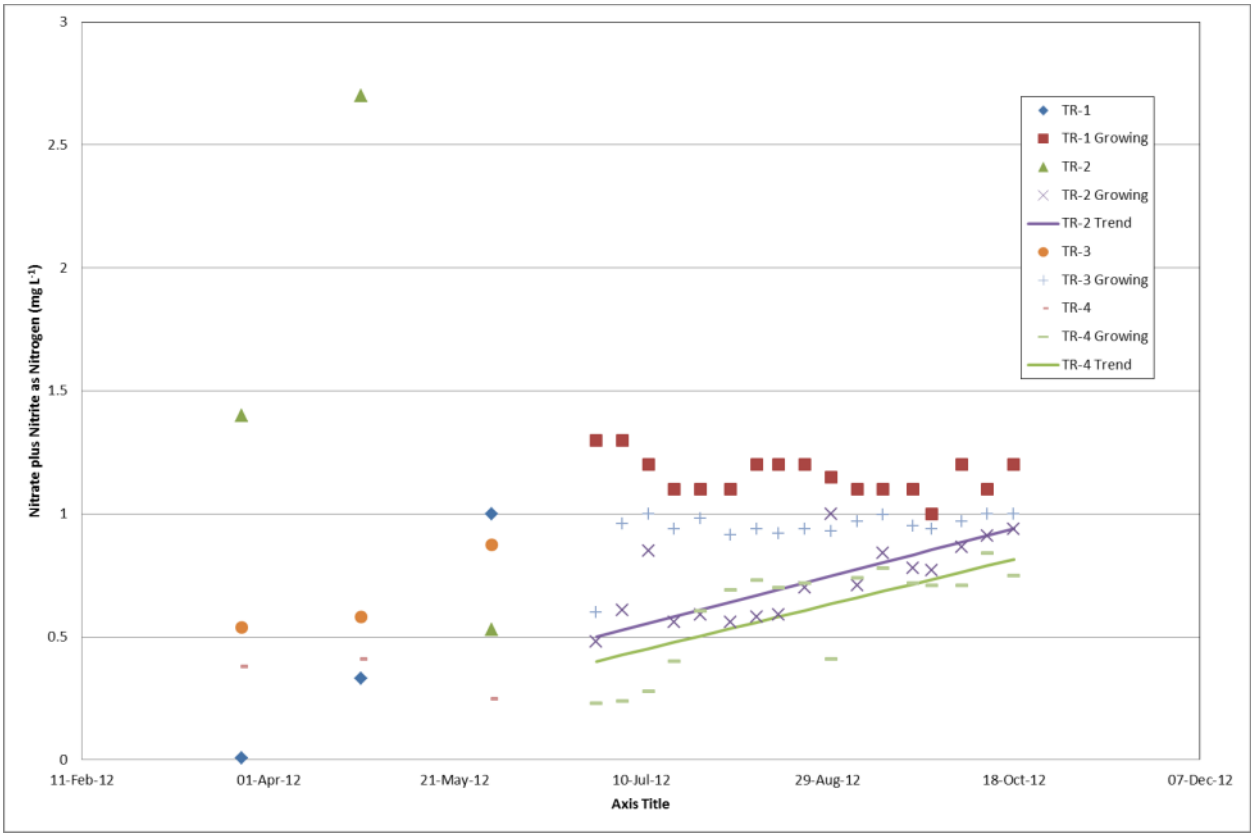


Figure I3. Nitrite plus Nitrate as N concentrations 2012, different symbols for non-growing/growing season for the sample sites, and including significant trendlines.

Based upon the weekly monitoring during the growing season (post peak snowmelt) there are significant differences in the nutrient concentrations spatially as well as temporally. The lowest sample location (TR4) in the study area also had the lowest nutrient concentrations. At TR4, the lowest sample location at the Highway 33 crossing, the average $NO_3 + NO_2$ as N was 0.60 mg L^{-1}, with a median of 0.71 mg L^{-1}, while average/mean TP was 0.016 mg L^{-1} with a median of 0.014 mg L^{-1} (Table I2). The highest growing season concentrations were measured at the uppermost sample location (TR1). The average $NO_3 + NO_2$ as N concentration nearest to the headwaters at TR1 was 1.16 mg L^{-1}, with a median of 1.15 mg L^{-1}, while average/mean TP was 0.020 mg L^{-1} with a median of 0.018 mg L^{-1} (Table I2). The TR2 and TR3 sites were in between the upper and lower sites with TR2 having slightly lower nutrient concentrations than TR3 which indicates a nutrient source in between. The most likely source is most likely a combination of the Driggs WWTP and the peat wetlands draining the Tepete peat through which Woods Creek flows and in which multiple springs surface and borders the Teton River (SCS 1969). However, this increase is attenuated downstream as the concentrations decrease by TR4.

Table I2. Chemical monitoring descriptive statistics, by location growing season 2012

Variable	Unit	Location	N	Mean	Median	StDev	Variance	Minimum	Maximum
TKN	(mg/L)	TR1	17	0.32	0.34	0.08	0.01	0.17	0.43
		TR2	17	0.35	0.35	0.09	0.01	0.22	0.54
		TR3	17	0.39	0.39	0.08	0.01	0.23	0.52
		TR4	17	0.36	0.38	0.08	0.01	0.23	0.46
NO2+NO3:N	(mg/L)	TR1	17	1.16	1.15	0.08	0.01	1.00	1.30
		TR2	17	0.73	0.71	0.16	0.02	0.48	1.00
		TR3	17	0.94	0.95	0.09	0.01	0.60	1.00
		TR4	17	0.60	0.71	0.20	0.04	0.23	0.84
Total N	(mg/L)	TR1	17	1.48	1.50	0.12	0.02	1.24	1.66
		TR2	17	1.08	1.06	0.16	0.03	0.83	1.46
		TR3	17	1.33	1.37	0.12	0.01	0.97	1.48
		TR4	17	0.97	1.00	0.20	0.04	0.58	1.22
TP	(mg/L)	TR1	17	0.020	0.018	0.009	0.000	0.013	0.048
		TR2	17	0.013	0.012	0.003	0.000	0.010	0.021
		TR3	17	0.024	0.023	0.005	0.000	0.016	0.037
		TR4	17	0.016	0.014	0.007	0.000	0.010	0.033
Chl-a	(ug/L)	TR1	15	0.86	0.79	0.37	0.14	0.22	1.70
		TR2	14	0.93	0.85	0.52	0.27	0.22	2.30
		TR3	14	2.34	1.80	2.24	5.00	0.82	10.00
		TR4	15	1.56	1.60	0.52	0.27	0.55	2.30

The decreasing concentrations along the channel length were confirmed using a Kruskal-Wallis non-parametric test which found significant differences in the $NO_3 + NO_2$ as N between the monitoring locations. The $NO_3 + NO_2$ as N concentrations are the lowest at the TR4 downstream sampling location. There were significant differences ($p < 0.001$) between the locations for $NO_3 + NO_2$ as N (Figure I3), TP and Chl-a, but there were none for TKN ($p = 0.081$) (Table I2 and Figure I4). The TR4 location typically had the lowest $NO_3 + NO_2$ as N concentrations, whereas the greatest were at TR1, so that the upper reach of the river had the highest concentrations. Total phosphorus and $NO_3 + NO_2$ as N concentrations decreased downstream, except for a slight increase at TR3, but between TR1 and TR4 the median $NO_3 + NO_2$ as N decreased from 1.15 mg L^{-1} to 0.71 mg L^{-1} and TP from 0.18 mg L^{-1} to 0.14 mg L^{-1}, respectively (Table I2 and Figure I3 and Figure I5).

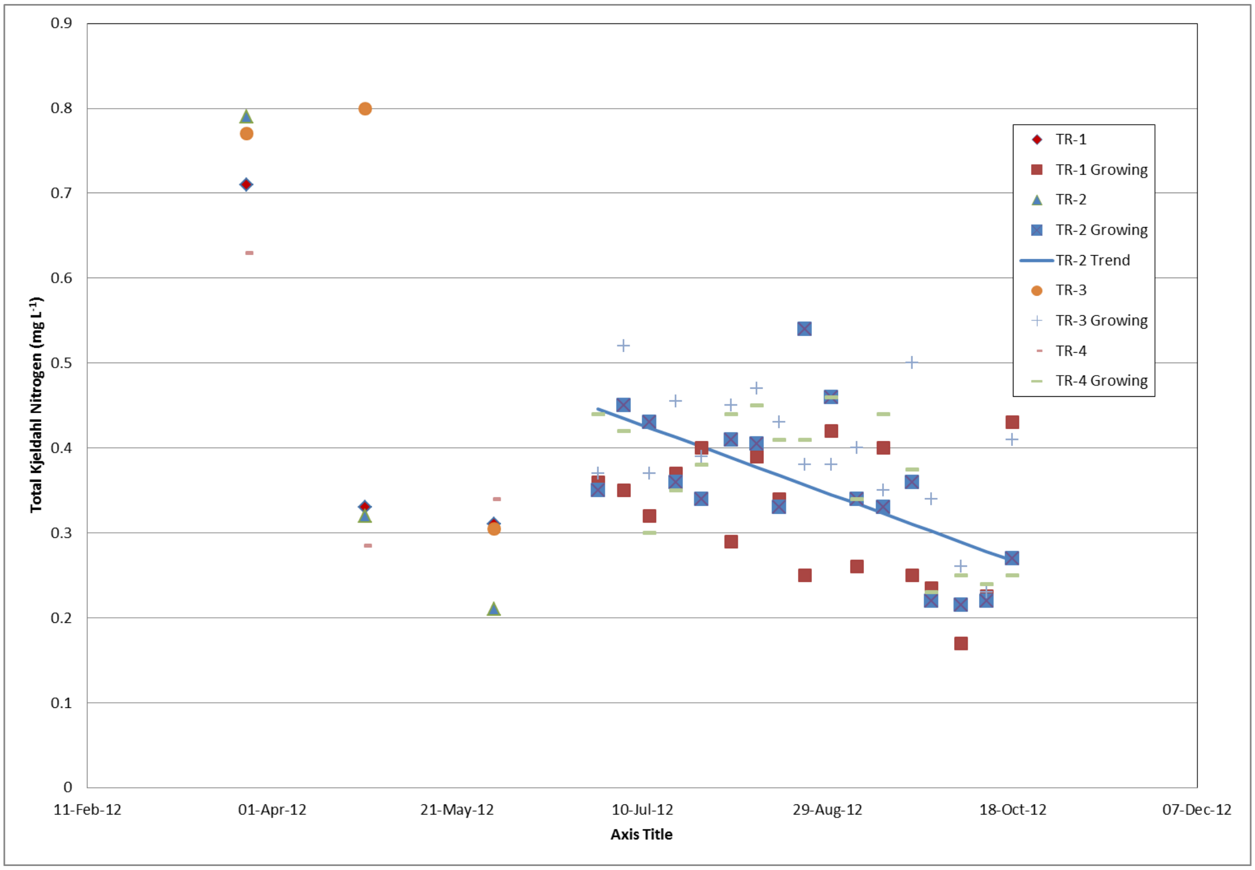


Figure I4. Total Kjeldahl nitrogen concentrations 2012, different symbols for non-growing/growing season for the sample sites, and including significant trendlines.

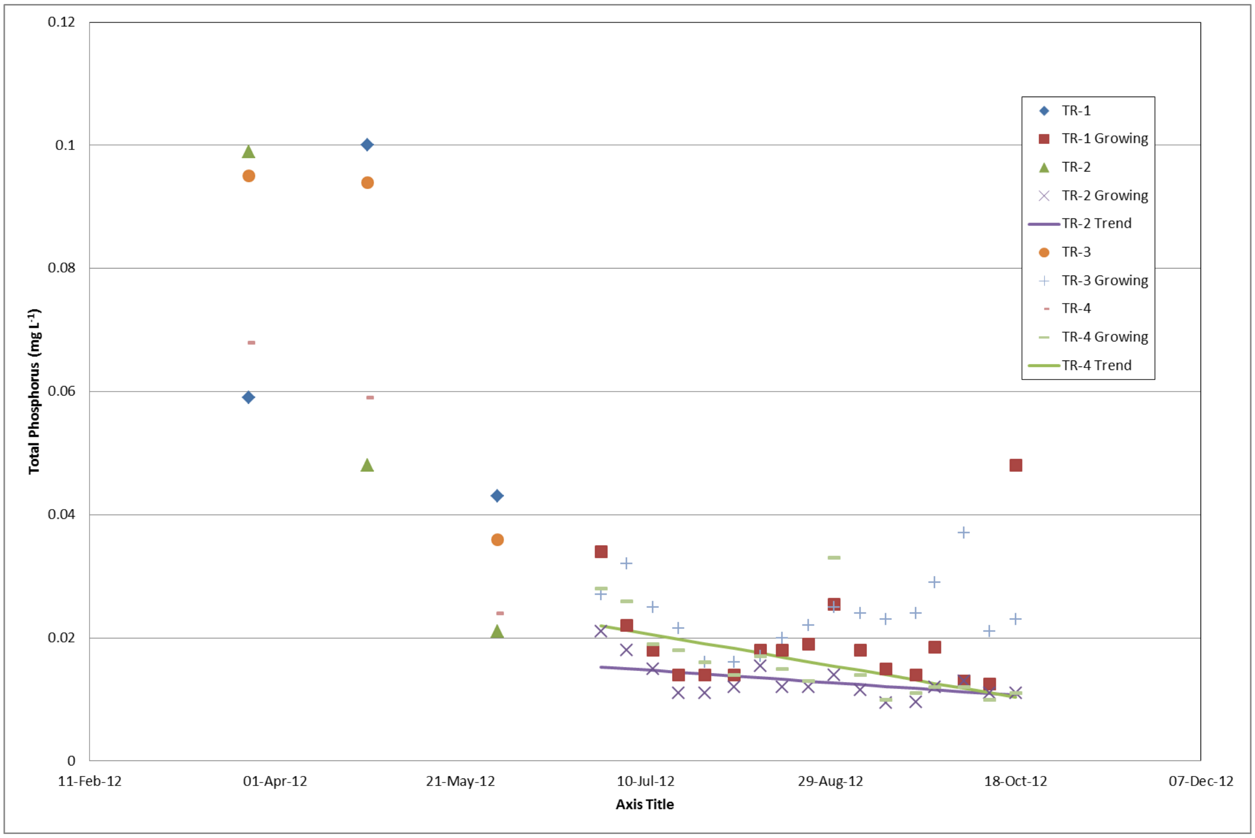


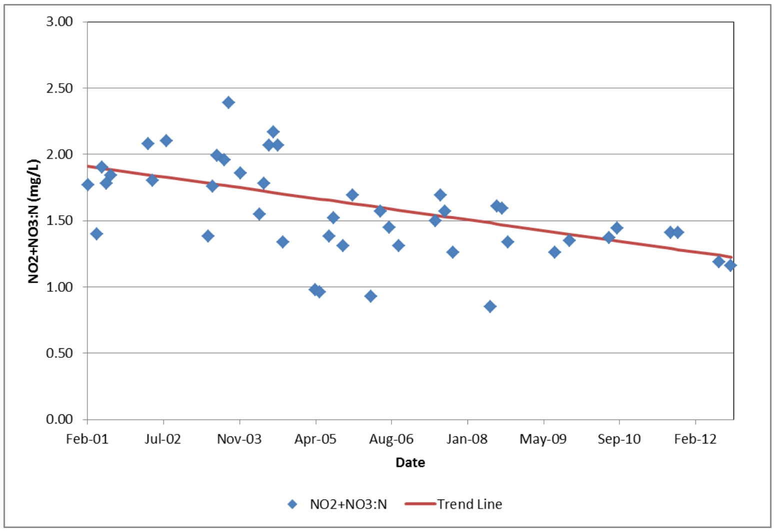
Figure I5. Total phosphorus concentrations 2012, different symbols for non-growing/growing season for the sample sites, and including significant trendlines.

At TR2 and TR4 there were increasing trends in the NO_3 + NO_2 as N concentrations during the growing season (late June to end of study period) at alpha = 0.01 (Figure I3), but there were decreasing trends for TP at both locations (alpha = 0.05) (Figure I5). However, TR1 had a decreasing tend for TN during the growing season (alpha = 0.05) (data not shown), but neither NO_3 + NO_2 as N nor TKN were identified as having trends at that location. TR2 had a decreasing trend for TKN (alpha = 0.05), which is in contrast to the increasing NO_3 + NO_2 as N trend (Figure I6). Total nitrogen (TN) was calculated from the sum of the NO_3 + NO_2 as N and TKN concentrations, it is believed that ammonia/ium concentrations are not significant in this portion of the Teton River. The TKN concentrations are variable through time and space (Figure I4) therefore the controlling consistency and bioavailability of the NO_3 + NO_2 as N is the more important to the study objectives for nutrient uptake and growth. Summary growing season TN and TKN data are included in Table I2.

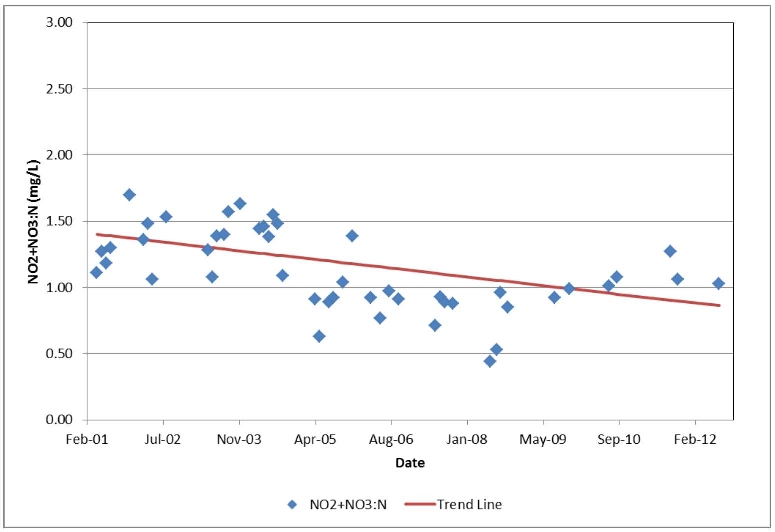
In 2012 FTR measured NO_3 + NO_2 as N concentrations similar to those measured by DEQ, which suggests that comparisons between these datasets are justified and not unduly influenced by potentially different sampling protocols (Table I3). When DEQ examined the long-term monitoring by FTR, there were downward trending lines in the NO_3 + NO_2 as N concentrations at all the sites with complete and comparable data (TR1, TR3 and TR4). The trendlines were found to be statistically significant at the alpha equal 0.01 level (Figure I6a-c). FTR discontinued their monitoring efforts at the TR2 location at the end of 2005, therefore no long-term comparisons are available between the DEQ collected data and that of FTR. There were no identifiable trends in the TP concentrations through time at any of the location using the FTR data. The number of samples below the TP detection limit between 2001 and 2012 and variable laboratory detection limits mean we cannot effectively develop any trendlines that provide useful information.

Table I3. DEQ vs FTR data, similar sampling dates

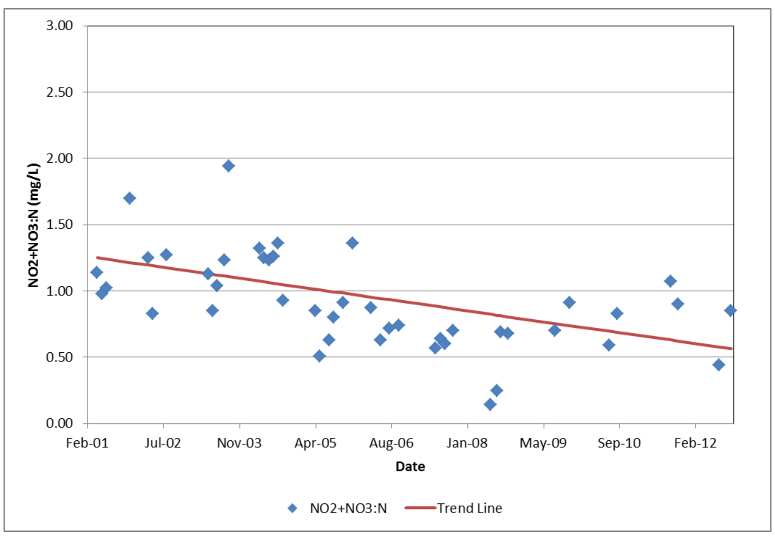
	July		October	
Location	**DEQ**	**FTR**	**DEQ**	**FTR**
TR1	1.1	1.19	1.2	1.16
TR3	0.94	1.03	0.97	1.01
TR4	0.4	0.44	0.71	0.85
Date	19-Jul-12	16-Jul-12	04-Oct-12	01-Oct-12



A)



B)



C)

Figure I6. FTR nitrate plus nitrite as N trendlines—A) TR1, B) TR3, and C) TR4.

Chlorophyll-a monitoring from the water column found that the maximum value was 10 µg L^{-1} at the TR3 location; this is believed to be an anomalous result. From all the other samples collected the maximum value measured was 2.3 µg L^{-1} while the minimum was 0.2 µg L^{-1}, more detailed results are listed in Table I2. The average water column Chl-a concentrations were 0.79, 0.85, 1.80 and 1.60 µg L^{-1} descending downstream from TR1 to TR4, respectively (Table I2). Benthic periphyton Chl-a from the DEQ River BURP monitoring measured a mean 25.3 mg m^{-2} Chl-a from 4 locations (each composited from 6 measurements in each study reach). The greatest Chl-a was measured at TR2 with 28.5 mg m^{-2} Chl-a and the lowest at TR4 with 22.9 mg m^{-2} Chl-a (Table I4).

Table I4. River BURP data - Benthic

Site	DEQ ID	Lab Benthic Chl-a (ug L^{-1})	Area tested (cm^2)	Volume (L)	Benthic Chl-a (mg m^{-2})
TR1	2012RDEQ001	380	72	0.5	26.4
TR2	2012RDEQ002	410	72	0.5	28.5
TR3	2012RDEQ003	340	72	0.5	23.6
TR4	2012RDEQ004	330	72	0.5	22.9

The River BURP monitoring and associated protocols were used to identify fish species present, macroinvertebrates, periphyton and associated Chl-a data; there were no indications that there were biologic impairments of the designated beneficial uses. The River Fish Index scores (RFI) fell into the highest categories with a range of cold water fishes and size classes (Table I5). The combined results from the River BURP electrofishing monitoring resulted in the collection/identification of 15 Rainbow Trout, 5 Cutthroat Trout and 92 Dace (Speckled and Longnose) (Table I5). Brook Trout and Sculpins also had significant numbers with 36 and 29, respectively. The largest fish, over 10 inches in length, were 3 Cutthroat Trout, 2 Rainbow Trout (both over 12 inches) and 26 Whitefish. There were numerous fish spotted outside of the electrical current and net reach and were not collected/identified. The species types, coldwater tolerance, numbers and age classes led to all 4 AUs being assessed into the highest category for fish species (RFI of 3) (Table I5). Macroinvertebrate sampling, via kicknet, found sufficient numbers of species, acceptable ratios of EPT (emphemera – plecoptera – tricoptera) and other factors to classify each AU into the highest category for the macroinvertebrate scores (RMI of 3) (Table I5).

Table I5. River BURP data – Macroinvertebrate and Fishes

DEQ ID	Location	RMI		SFI	
		Score	Condition	Score	Condition
2012RDEQA001	TR1	19	3	86	3
2012RDEQA002	TR2	17	3	91	3
2012RDEQA003	TR3	19	3	76	3
2012RDEQA004	TR4	23	3	76	3

The YSI sonde data identified potential temperature exceedances in the Teton River at the latest potential extent for spawning/rearing of trout in the mainstem of the Teton River. That analysis is examined more closely in Section 5 and subsequent monitoring identified exceedances and TMDLs for temperature were developed. These temperature exceedances were identified at both locations. At the TR1 location, there were diel depletions of the DO in the late evening/early mornings that were identified (data not shown). However, these were not measurements of the interstitial DO nor were they related directly to anthropogenic sources. Any DO depletions were from the growth of rooted aquatic macrophytes and not by algal nuisance growths of or similar plants or die-offs (Chambers et al. 1999). These low DO concentrations cannot be directly related to the dissolved nutrient concentrations, but are related to the sediments supplying nutrients to the rooted macrophytes.

Discussion

The peak in the snowmelt hydrograph provides a natural separation to examine the surface water in the upper Teton River valley. When examined based on the time of year, prior to the snowmelt peak of the annual hydrograph corresponds to the highest measurements of TP, TKN and many of the NO_3 + NO_2 as N. This suggests that the snowmelt process essentially ‘flushes’ nutrients into the river from the soil surface and/or shallow groundwater. Whereas on the falling limb of the hydrograph that initial flush of nutrients and sediment subsides and the remaining water dilutes the N and TP concentrations in the river. By the time baseflow conditions are reached the primary water source to the river is from shallow groundwater and wetland sources.

The NO_3 + NO_2 as N concentrations in the upper Teton River have varying, but significant trends. During the growing season there are increasing statistically significant trends for NO_3 + NO_2 as N at TR2 and TR4. Increases in the NO_3 + NO_2 as N concentrations at the TR2 and TR4 locations are related to a lack of dilutional flow. A limited dilutional flow response suggests that transport of organic and sediment-bound chemicals is also limited, thus the decreasing trendlines for TP at TR2 and TR4, and for TKN at TR2. Examination of the NO_3 + NO_2 as N data suggest that from mid-August through the end of the monitoring in 2012 at TR4 were less variable than earlier in the season. These late-growing season concentrations indicate that the groundwater inputs and water quality during baseflow influences the river water quality. The NO_3 + NO_2 as N concentrations near the end of the growing season at TR4 are approximately 0.75 mg L^{-1}. Groundwater analysis by Niklin (2003) found that the wells in the upper Teton Valley had NO_3 as N concentrations that averaged 1.07 mg L^{-1} as N in the shallow wells (<100 ft depth) nearest to the river. The extent of the groundwater contribution to the overall in-channel discharge in the Teton River from these shallow wells and aquifer is not known, but it is presumed to be a gaining river from the groundwater during baseflow conditions. Therefore groundwater inputs account for a portion of the NO_3 + NO_2 as N in the Teton River and are similar to the shallow well concentrations. Baseflow conditions are also expected to cause the peats and wetlands that parallel the river to act as a nutrient source, particularly dissolved nutrients as those areas are often up-gradient of the river system and are believed to be directly hydrologically inter-connected. Irrigation return surface flows do not appear to be a source as most irrigation and harvest in the upper valley was completed before the end of the study period, and concentrations persisted at their pre-harvest concentrations. This does not suggest that groundwater NO_3 + NO_2 as N concentrations are not related to irrigation, nor does it confirm that interpretation, but only that surface return flows do not appear to be primary the pathway for the NO_3 + NO_2 as N.

Covino et al. (2010) found that there was a biologic response to changing nutrient levels so that nutrient uptake was controlled by the *in-situ* concentrations, meaning that greater nutrient concentrations led to slower/lesser biologic uptake. Since the summer 2012 was a dry year, the expected dilutional surface water was not available to dilute the GW inflows therefore DEQ believes we have conservative nutrient monitoring measurements at baseflow, especially at locations TR2 and TR4 which had increasing trendlines throughout the growing season that had approximate endpoints similar to measured GW concentrations at nearby shallow wells (Niklin 2003). Additionally, there is a strong decreasing trend through time (based upon the FTR data) that suggests that there are lower concentrations in the NO_3 + NO_2 as N than a decade ago.

Driggs WWTP discharges into Woods creek, the confluence with the Teton River is approximately 1.3 river miles above the TR3 location. There is a slight increase in the nitrogen concentrations at TR3 (below this confluence) as compared to TR2. It was determined that the WWTP is not a significant source to the measured nitrogen concentrations in the upper Teton River as there is an overall decrease in nitrogen concentrations between TR1 and TR4 suggesting that the slight increase at TR3 may or may not have been directly to the WWTP, the peat wetlands or to some other unidentified source. The nitrogen concentrations at TR4 were the lowest in the entire study area, indicating that there is nutrient attenuation, uptake and utilization in the study reach (Figures I3 and I5).

The TP decreasing trend at TR4 during 2012 suggest: (1) that as discharge and the associated stream power decrease through the summer months so do the TP concentrations in the upper Teton River which suggests that there is a connection between mobilized sediment/soil and TP concentrations, and (2) the sediment/soil carrying the TP does not appear to be related to irrigation water return flows which are expected to be greatest during the late summer when irrigation requirements and return flows are greatest. This does not imply that agricultural lands are not nutrient or sediment sources during spring runoff and storm-events, but that irrigation management does appear to be effective when examined at TR4 as an indicator for the entire contributing area upstream during the growing season. Observations by DEQ and examination of the streambank erosion indicate that there are many locations that could benefit from more rigorous application of BMPs to limit soil-bound phosphorus from reaching the stream channel.

The NO_3 + NO_2 as N concentrations were found to be elevated when compared against some of the literature recommendations, however, Idaho uses a narrative criteria and impairments are based upon nuisance levels of aquatic plants and not literature derived recommendations. The only location that could be identified as having potentially high nuisance levels of aquatic plants was at the TR1 location. This location had approximately 60-70% of the substrate covered with what was appeared to be Potamogeton spp. The stream type classification for the TR1 location is more similar to a spring creek than the lower reaches, with significant groundwater inputs and a low gradient. This macrophyte covered substrate is the expected condition for this type of stream and in this environment. The substrate was composed of fine particles, (i.e. silts and organic matter), except for the thalweg which had more gravels. The one concern of the macrophytes was the DO depletions during the night as the plants changed from photosynthesizing to respiring and DO concentrations dropped. These DO concentrations were not impairing the health of the trout fisheries, as indicated in the electrofishing RFI scores. Additionally these depletions are from the macrophytes and a natural process associated with spring creeks. There were no prolonged periods where the DO was low and below the standards that would lead to an impairment listing. The cause of the DO sag was an observed effect from the macrophytes growth (which are rooted in the substrate/sediment), therefore the nuisance growth is not related to the dissolved nutrient loads, but the nutrients within the sediment, since there is a TMDL load for sediment being re-vised and updated for the upper Teton River, this is expected to address the actual cause of the DO sag and more directly control the source. Reisinger and Tank (2013) found that found that biofilms were either growth limited by P or co-limited by N and P in the Teton River, which are dependent upon nutrients in the water column. Mebane et al. (2014) in a study of agricultural streams and spring-fed streams in the upper Idaho Snake River basin, found no correlation between either the water column nitrogen or the sediment nitrogen on macrophyte growth; instead the loosely sorbed phorphorus in sediment had a more meaningful correlation to the macrophyte growth. These studies support the supposition that the macrophyte growth in the upper Teton River is due to the sediment phosphorus; therefore management of the macrophytes should first examine limiting sediment inputs which transport TP into the river.

Developing a nutrient impaired determination for the upper Teton River is complicated by recent findings that determining trophic states in rivers is more appropriately related to plant growth and not measures of TN or TP (Chambers et al. 1999; Maret et al. 2010). Maret et al. (2010) extrapolate their conclusions by discussing the different approaches needed to examine macrophytes, which are rooted plants, versus macroalgae, which derive nutrients from the water column. When the concerns of trophic state analysis (Maret et al. 2010) and loosely sorbed sediment phosphorus (Mebane et al. 2014) are examined against the macrophyte growth in the upper Teton River it becomes apparent that the concern is with the sediment entering the system and promoting the growth of rooted macrophytes, and an examination of nutrients in the water column and nuisance growth needs to be appropriate for the dominant growth and subsequent determinations of eutrophic state.

Chlorophyll-a sampled off of rocks (i.e. periphyton) from a study “Assessing biofilm nutrient limitation as an indicator of water quality in the Teton River” (Reisinger and Tank 2013) found that the 125 mg m^{-2} Chl-a was less than the 150 mg m^{-2} Chl-a identified by Montana DEQ as being excessive and a nuisance level (Suplee et al. 2009). This supports DEQ’s interpretation that the nutrients leading to excessive growth are not meeting the threshold of being considered a nuisance and are not within Idaho’s definition of a nutrient impairment. The results of the Reisinger and Tank (2013) study are approximately 5 times greater than what was measured during the 2012 River BURP monitoring. The DEQ River BURP monitoring measured a mean 25.3 mg m^{-2} Chl-a from 4 locations (each with 6 composited transect measurements along the river corridor) contrasting the single location with replicates from Reisinger and Tank (2013). There may be a seasonality component, or other differences between years that were not examined. In the Teton River problems related to excessive nutrients do not directly correlate with the dissolved/bioavailable nutrients but are more related to sediment impairments and inputs of TP, which is typically imported into aquatic environments via its attachment to soil particles.

There are no NPDES point sources in the uppermost AU of the Teton River, TR1, which had the consistently highest measured nutrient concentrations. Therefore all nutrient additions in this area are from nonpoint sources, which require BMPs to manage. Sediment loads and nutrient recycling can explain a significant portion of the $NO_3 + NO_2$ as N and the TP concentrations in the water column based on assumptions of mass nutrients in the sediment that is eroded and transported in the river system.

When the chemical measurements are examined for effects upon the beneficial uses, DEQ cannot identify an impairment that is caused by excessive nutrients and/or nuisance growth. Fish populations were good, with significant numbers of cold water trout species. The macroinvertebrate counts and EPT were found to be indicative of healthy streams. However, 3 of the 4 AUs of the upper Teton River have approved TMDLs because of sediment impairment, whereas the fourth has a TMDL developed for sediment in this TMDL (See section 5.2 and Appendix C). The sources were typically found to be identifiable by in-channel deposits and bank erosion. These primary in-channel sources/deposition zones have led to portions of the river to have high W-D ratios and areas with limited high quality fisheries due to the sediment inputs into the system. Several tributaries are identified in the 2003 TMDL and those deposits (along with in-channel bank erosion) were found to be fouling the gravel substrate in about 10% of the river reach with fine sediment particles. This sediment issue is discussed further in section 5.2 and Appendix C.

SW/GW interactions are heterogeneous which has the potential for nutrients loads into streams be variable through time and space (Dahm et al. 1998). Therefore the nutrient concentrations identified by Niklin (2003), may not represent the concentrations reaching the channel. Restoration efforts to reconnect GW/SW can lead to improved nutrient retention and removal from the groundwater and surface water (Mayer et al. 2010). These results have implications for remedial actions that are currently required to limit sediment and heat inputs into the Teton River. It is expected that the efforts to stabilize banks and increase shading will decrease the width-depth ratios, increase thalweg and pool depths, as well as increase groundwater (and nutrient) uptake by the common practice of developing a more robust and woody-plant (i.e. willow) based riparian area (Wohl et al. 2005; Dosskey et al. 2010).

In-channel restoration can lead to improved pool condition (i.e. increased microbial activity), which were found to have increased rates of denitrification as compared to riffles (Lefebre et al. 2006). This suggests that improved substrate condition with pools less full of sediment should be micro-locations for nitrate/nutrient removal once sediment loads are decreased in the Teton River. Improved riparian habitat typically includes livestock exclusion to promote and maintain plant growth and bank stability and has been identified as reducing nonpoint source pollution, especially TP (Line et al. 2000). Therefore goals associated with known and identified sediment impairments are expected to have secondary results that will improve the nutrient retention, and uptake in the GW/SW interface leading to an increased functioning condition of the river. The expected BMPs required to manage bank erosion should have secondary and tertiary effects to limit nutrient inputs by limiting direct inputs from the sediment and additional nutrient uptake by the woody plants from the groundwater, thereby creating what could be considered a subsurface buffer by altering the SW-GW interactions.

To summarize the findings in downstream direction (northward), the TR1 location has the consistently highest $NO_3 + NO_2$ as N concentrations and the second highest TP concentration; it is also the location with the greatest groundwater inputs relative to the total discharge. It is essentially a low gradient spring creek with high sediment (fines) inputs and the greatest macrophyte populations covering the substrate. It is also the only location that had the TN concentrations decreasing through 2012. Like the other sample locations, it has baseflow $NO_3 + NO_2$ as N concentrations that appear to be related to the groundwater

The TR2 location is below the "Big Bend" stretch of the river and what appears to be a surface water hydrologically connected wetland in a low topographic relief area. It is expected that this wetland serves both as a source and a sink for the nutrients and as conditions change throughout the year. This channel morphology is controlled by the alluvial fans from either side of the valley (West side – Mahogany Creek: East side – Fox Creek region) creating a natural barrier that lessens the stream gradient and promotes the SW-GW interaction. The concentrations of all the nutrients were smaller at the TR2 location than at the TR1 location, and the TR3 location. There are substrate sediment and bank erosion issues in this location. It should be noted, that while examining the banks and substrate for sediment issues, there was a low intensity rainstorm and the run-off waters from nearby field did not appear to carrying sediment as the waters were clear (i.e. not turbid). Unfortunately due to wet and snowy weather conditions the camera was not fully operational on that September day.

The TR3 location is below the confluence with Woods Creek, which transports the WWTP discharge to the Teton River. While we did identify an increase in the nutrients (compared to TR2) at this location; we identified many locations upstream and downstream of this site that had severe bank erosion and also were sources of nutrients to the channel. DEQ determined that since these concentrations dropped to below the TR2 levels by the time the waters reached the TR4 that there was capacity to convert and attenuate a portion of the nitrogen in the system. Limiting nutrient inputs from sediment will help maintain functionality of the beneficial uses within the current WWTP wasteload (since no impairments are identified as being related to nutrients, there is no need to develop new allocations and permits numbers). It is not known what the nitrogen dynamics are as the peat soils dry and re-wet throughout the year and whether they act as a long-term sink or source, or are seasonal for each (Cabezas et al. 2012).

The TR4 location has dual constraints that have altered the beneficial uses. The first is the highway bridge; the second constraint is approximately 1 river mile upstream of the highway and the erosion of the volcanic upland/foothills that is a massive source of sediment to the channel. Most of this is a partially decomposed rhyolite that does not introduce fine soil particles into the river, but does alter the width-depth ratio downstream and create a fishery suitable to the daces most likely due to the riffle habitat. This is a natural occurrence as aerial photographs of this area have multiple overgrown scalloped sections of this foothill that periodically becomes eroded as the river moves its channel through the natural processes associated with a low gradient highly sinuous system geomorphology. This location had some of the lowest median/mean nutrient concentrations in the study.

Conclusions

This summary and study have determined that the Teton River has the capacity to utilize and transform the majority of the nutrients introduced to the river; if not controlled, but additional inputs from the excessive sediment supply could shift the current functionality. There are developed implementation plans for the Teton River subbasin and there have been significant improvements to the agricultural practices since the 2003 TMDL, but there are still residual pockets of sediment overlying the substrate and banks that have been allowed to become unstable, and areas with spring snowmelt induced hillslope erosion. In short, the upper Teton River in the valley section has urban developments and land-uses which have imposed constraints on the river, but in areas where those constraints are lifted the river tends to erode both banks (skewing the width-depth ratio) instead of developing bends and thalwegs. Development and maintenance of stabilizing vegetation should help promote a more stable streambank, decreased sediment inputs with the added benefits of increased shading (lower heat/energy input) along with greater utilization of the GW nutrient inputs. There is not a current nutrient problem in the Teton River; overall improvements in the land-use activities are required to ensure that this section of the river does not diminish in quality.

While there were no identified impairments to the fisheries or biology and associated beneficial uses in the upper Teton River, three of the four AUs of concern are have TMDLs for sediment impairments and have updated TMDLs developed for those locations in this document. The fourth AU is receiving a new sediment TMDL in this document. There are data from 2014 that indicated the temperature exceeds the spawning criteria in the Upper Teton River and TMDLs have been developed to improve the fish spawning habitat conditions. Based upon the geology and soils in the upper section, the recommended BMPs are essentially the same to improve river temperature and habitat conditions. Being that there is only one NPDES permitted discharger (which was not identified as a significant nutrient source), recommendations for improvements to meet nutrient goals would be directed at non-point source BMPs and are also similar to the recommendations that would support temperature/shade and sediment improvements in the waters. Since the sediment loads carry nutrient concentrations into the river, both as a source and pathway, DEQ believes that controlling for the sediment load is the first and primary concern to manage for to improve nutrient concentrations and habitat. Bank stabilization will improve habitat through woody-plant root growth and promote narrower streams that are both more effective at transporting sediment and that have width-depth ratios that are more indicative of a channel supporting high quality fisheries.

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Appendix J. Public Participation and Public Comments

William Stewart, US Environmental Protection Agency

Thank you for the opportunity to review this document and I found it to be complete and well done. I have a few comments at this time concerning this document.

Thank you for taking the time to review and comment on this document.

- A wasteload allocation must be provided for each point source that discharges to an impaired stream or upstream of an impaired stream that may be affected by the discharge. I didn’t see clear wasteload allocations for NPDES permitted locations, like Driggs for instance.

  We agree that the wasteload allocations were insufficiently addressed. The Driggs WWTP was given a wasteload allocation in Section 5.3.4.

- You need to be sure to include “daily loads” for each parameter you are doing a TMDL for. There doesn’t seem to be a problem with the PNV temperature TMDLs. You need to be clear on load allocations and wasteload allocations that the TMDLs are expressed as daily loads and not annual loads, percent reductions, or other units. This is due to some recent court decisions that need to be followed.

  Daily loads were calculated for sediment and bacteria. These values replaced the previous load allocations in Table 31 and Table 34.

- I had a hard time figuring out your calculations for sediment in particular. Please review these calculations and make sure that they are correct before submitting the TMDL for approval. More explanation may be required as to how the allocations were developed.

  We discovered our sediment calculation error after the document had been released for public comment. The error resulted from a typo within our sediment calculation spreadsheets. The formula was calculating the margin of safety at 10% of the current load rather than 10% of the loading capacity. We have corrected this calculation error and replaced the incorrect sediment values. Additionally, we corrected additional calculation issues for the four Teton River AUs (017_04, 020_04, 026_04, 028_03), whose inventories were completed via a river float.

- Perhaps a stand-alone table for each section; for temperature, bacteria, and sediment clearly stating the daily load allocations and wasteload allocations would make the TMDL more understandable.

  The daily load allocations are reflected in Table 27, Table 31, and Table 34, which are the nonpoint source load allocation tables for each pollutant. The wasteload allocation is provided in Table 35.

It is refreshing to see a complete, well thought out document for temperature and sediment on these river basins. I look forward to working with you on the approval process for this document and wish you success in completion of an implementation plan to improve your waters.

> *Thank you for your comments, and we greatly appreciate your involvement prior to official submission of the document for approval.*

Appendix K. Distribution List

Bill Stewart, EPA

City of Driggs, Idaho

Friends of the Teton River

Henrys Fork Watershed Council

Idaho Fish and Game

Idaho Soil and Water Conservation Commission

Upper Snake Basin Advisory Group

US Forest Service